# RETURN

Answer to an Address of the House of Commons of the 22nd March, 1909, praying that His Excellency the Governor General will cause to be laid before the House a copy of all correspondence, reports, documents, Orders in Council, in possession of the Government relating to the establishment of a Geodetic Service Bureau and the commencement of a Geodetic survey in Canada.

CHAS. MURPHY,
*Secretary of State.*

# CONTENTS.

*Sessional Paper No. 145.*

PAGE.

# CONTENTS.

*Sessional Paper No. 145a.*

# CONTENTS.

*Sessional Paper No. 145b.*

# MEMORIAL OF THE DOMINION LAND SURVEYORS ASSOCIATION TO THE MINISTER OF THE INTERIOR, MARCH, 1886.

*The Honourable the Minister of the Interior:*

SIR,—The following Memorial is respectfully submitted for your consideration by the Association of Dominion Land Surveyors.

The Dominion has arrived at that stage when the wants of the country demand a more exact system of survey than has been in vogue in the past. With the increase in the value of real property—the boundaries of which in the older provinces are in most cases entirely dependent for their stability on the durability of a piece of wood, a few marks on trees or the testimony of a few of the oldest inhabitants, thus often leading to expensive litigation, of which the result is dependent mainly on the preponderance of evidence on one or the other side, which may be, and is often wrong—increases also the necessity for such a survey. Now, were the boundaries—especially those of large areas, such as concessions, townships and counties—connected with, and defined by a geodetic survey, similar to that made by the countries mentioned herein, all doubt as to their true position would be forever set at rest. Also the demands for marine purposes of more accurate charts of our coast, and waters, show that an accurate coast and geodetic survey of the country is urgently needed.

The question of the value and utility of a survey of this kind has been so settled by almost every civilized nation, that it is hardly necessary to advance further proof of the fact, but for information the following may be presented. It is stated by an eminent American engineer that 'if the state of Massachusetts had had a good topographical map in 1836, some $20,000,000 would probably have been saved in its public railway expenditure.'

Mr. Sandford Fleming, in his report to the Minister of Public Works, dated the 5th of April, 1879, says: 'If the railways of Ontario had to be established de novo, a careful study of the requirements of that province would enable any intelligent engineer of ordinary experience to project a new system, which at one-half the cost would far better serve the public, would meet every demand of traffic, would more fully satisfy every expectation and which would not result in disappointment and loss to those who have been induced to invest their means in that which has proved to many an unprofitable undertaking.' The railways of Ontario have cost, according to official returns, nearly one hundred and eighty millions of dollars. If they could have been constructed at one-half the cost, the other half of this enormous expenditure may be assumed to be a wholly unnecessary outlay, if a well-considered and less costly system would have equally met the wants of Ontario. The excessive expenditure can only be considered as superfluous, and so much of it remains permanently unremunerative as to be hopelessly wasted. If public money, the public debt might have been so much the less, or other interests might have been served and developed to the extent of the increased expenditure. If private money, obtained from parties at a distance on fair promises, or on prospects represented as encouraging, there is staring the investors in the face the deplorable and impregnable fact, that much of it will be absolutely lost.

If to-day a railroad is projected in England, preliminary surveys such as we are obliged to make are not necessary. From the plans provided by the ordnance survey, the lengths and grades of any proposed line can be laid down with sufficient accuracy to enable a final location to be made.

These plans are also very valuable in determining drainage areas; water supply; boundary lines between estates; reclaiming tidal lands, and materially assist in equitable assessment of real estate for taxes.

The surveys of this kind which have been made by other countries may be summarized as follows:—

First and foremost is the Ordnance Survey of Great Britain and Ireland, covering nearly 111,000 square miles, which was begun in 1784 and is now nearing completion. The original scale is one inch to the mile, but afterwards six inches to the mile was adopted. Then comes the great Trigonometrical Survey of India, inaugurated at the beginning of the present century by Colonel Lambton, and which is still in progress, and of which the beneficial results have been inestimable. Belgium, with an area of about 10,000 square miles, will have 450 sheets when the survey is completed. The scale adopted is $\frac{1}{20000}$, and the contour lines are one metre apart.

In Prussia, since 1849, new and more perfect methods have been introduced into the government topographical surveys.

In Baden a new map was commenced in 1874, on a scale of $\frac{1}{25000}$, and with contour lines 10 metres apart.

In Saxony the original survey was commenced in 1780 and completed in 1806, on a scale of $\frac{1}{12000}$, and a new map was finished in 1870.

Russia, with its enormous territory, about twice the size of the United States, including Alaska, has been for many years actively engaged in prosecuting geographical surveys.

Norway, although a comparatively poor country, has set itself on having a good topographical map, on a scale of $\frac{1}{100000}$, and its work merits praise.

Sweden, similarly, is prosecuting such work and has one-half thereof completed.

Bavaria in 1868, completed her map in 112 sheets.

Wurtemburg has also a map, on a scale of $\frac{1}{50000}$, of which a new edition is in progress.

Austria has completed a new map, comprising 715 sheets.

In Switzerland a new map of 546 sheets is being issued.

Denmark has a survey in progress.

The great map of France is comprised in 276 sheets.

Italy is being mapped on a scale of $\frac{1}{50000}$.

Spain has been engaged since 1838 on a new survey, and Portugal since 1856.

On this continent surveys of a high order of precision have been made by the United States government along the coast of the United States and along the great lakes. They have also been made over many of the States and territories of the far west, including Nevada, Colorado, Utah, New Mexico, Montana, Idaho, and part of Arizona.

Several States have made similar surveys of their territory, including Massachusetts, California, New Jersey and New Hampshire, and in other States they are in progress.

All the foregoing surveys both in Europe and America are based upon a triangulation. The necessity of such work is proved by experience and is so settled that it can no longer be considered an open question.

A similar survey of Canada, especially of the more thickly populated part of her ocean shore line must and will be made, as a natural consequence of her continued development.

The loss of a single vessel with her cargo through ill-defined rocks or reefs, or inadequate and unreliable charts would be sufficient to pay for thousands of square miles of survey.

The United States coast and Geodetic survey has already made a number of connecting links into Canada for our future use.

Already surveys of more or less precision are being made, and a general coast and geodetic survey is pre-eminently one to be undertaken by the Federal government.

In a work of such proportions as a survey of this kind would ultimately assume, it is primarily essential that a well matured and carefully considered scheme be first

laid down upon which to develop the whole work, and being guided by the experience of other countries it is evident that a primary triangulation is necessary as a ground work for all detail surveys.

For the initiation of the work, and that a beginning may be made in this much needed survey, the following scheme is respectfully submitted:—

That the work should be conducted under the direction of the Department of the Interior, which is provided with the expensive instruments required in work of this nature, and is well able to undertake such a survey from the fact, that it has in its employ a number of surveyors who are qualified by the examination provided by the Dominion Lands Act to undertake extensive topographical and governing surveys, thus rendering it unnecessary to apply to the Imperial government for scientific men to prosecute such work; and also from the fact that very exact surveys of this nature have already been conducted by that department in the Northwest territories.

A survey of this sort is most urgently needed in the older provinces, and in consideration of the fact that an early survey of the Gulf of St. Lawrence has been promised, the work might be initiated there by a Trigonometrical and intermediate coast, and sounding survey with all necessary tidal observations, as the same would be invaluable as an aid to navigation. The Department of the Interior being in possession of the instruments required for such work, a comparatively small yearly expenditure would suffice for extensive field operations.

A chain of primary triangulation along the St. Lawrence river and gulf, also the great lakes, would provide a basis for the extension of the survey into the interior of the different provinces, as the same become necessary, and could readily be connected with the United States lake survey.

In consideration of the foregoing facts, your memorialists respectfully submit that it is to the interest of the country at large that a trigonometrical survey such as is suggested should at once be begun.

And as in duty bound your memorialists will ever pray.

Signed on behalf of the D. L. S. Association.

THOMAS FAWCETT,
*President.*

GRAVENHURST, March 25, 1886.

## MEMORANDUM OF THE DOMINION LAND SURVEYORS ASSOCIATION PRESENTED TO THE GOVERNMENT IN 1888.

AT THE FIFTH ANNUAL MEETING OF THE ASSOCIATION OF DOMINION LAND SURVEYORS, HELD AT OTTAWA, ON THE 14TH AND 15TH OF MARCH LAST, (1888), A COMMITTEE WAS APPOINTED TO CONSIDER THE QUESTION OF A TRIGONOMETRICAL SURVEY OF THE DOMINION, TO DRAFT A SCHEME FOR ITS INCEPTION, AND TO TAKE SUCH STEPS AS THEY MIGHT DEEM ADVISABLE TO BRING THE SUBJECT UNDER THE NOTICE OF THE GOVERNMENT, AND OF OTHERS LIKELY TO BE INTERESTED IN THIS MUCH NEEDED WORK.

The Committee beg to submit the following in reference thereto:

The Dominion has now arrived at that stage when the wants of the country demand a more exact system of survey than that in vogue.

The question of the value and utility of a trigonometrical survey has been so settled by almost every civilized nation, that it is hardly necessary to advance proof of the statement that it would be of immense practical value to the whole Dominion; but for illustration, and in support of the statement, the following facts are offered.

The surveys of this kind, which have been made by other countries, may be briefly referred to.

First and foremost is the Ordnance Survey of Great Britain and Ireland, covering nearly 111,000 square miles, which was begun in 1784, and is now nearing completion.

Then comes the great Trigonometrical Survey of India, inaugurated at the beginning of the present century by Colonel Lambton, which is still in progress, and of which the beneficial results have been inestimable. Belgium is carrying on a survey which, when completed, will furnish 450 sheets of map on a scale of 1/20,000 with contour lines one metre apart.

Prussia is carrying on an extensive survey, and since 1849 has introduced new and more perfect methods. Russia, with its enormous territory, about twice the size of the United States, including Alaska, has been for many years engaged in prosecuting trigonometrical surveys.

Norway, although a comparatively poor country, has set itself on having a good topographical map, on a scale of 1/100,000 compiled from trigonometrical surveys.

Austria has completed a new map of the empire, comprising 715 sheets also compiled from data furnished by trigonometrical surveys.

Denmark, Switzerland, Spain, Portugal and Italy are all carrying on trigonometrical surveys to enable them to map their territories accurately.

France has completed her survey, and the result is shown in 276 sheets of map.

On this continent, surveys of a high order of precision have been made by the United States government, and the work of the Coast and Geodetic Survey is going steadily on, having been extended along the sea coast and also along the Great lakes, and many of the states and territories have been covered by its operations, including some in the far west, viz.: Nevada, Colorado, Utah, New Mexico, Montana, Idaho and part of Arizona.

Several of the states have conducted independent trigonometrical surveys of their own territory, including Massachusetts, California, New Jersey and New Hampshire, and in other states they are in progress.

All the foregoing surveys are based on triangulation.

It may be asked what are the practical benefits to be derived from a trigonometrical survey, and what is there to justify the expenditure of the large sum of money which a survey of this kind would ultimately cost. To make the point of practical benefit clear, the following will be readily understood by all:

It is stated by an eminent American engineer that 'if the state of Massachusetts had had a good topographical map in 1836, some twenty million dollars would probably have been saved in its public railway expenditure.'

Mr. Sandford Fleming, C.M.G., in his report to the Minister of Public Works, dated April 5th, 1879, says: 'If the railways of Ontario had to be established "de novo," a careful study of the requirements of that province would enable any intelligent engineer of ordinary experience to project a new system which at one half the cost would far better serve the public, and would meet every demand of traffic, would more fully satisfy every expectation, and which would not result in disappointment and loss to those who have been induced to invest their means in that which has proved to many an unprofitable undertaking.'

If to-day a railroad is projected in England, or any other country possessed of a good topographical map, preliminary surveys such as we are obliged to make are unnecessary, for from these plans the lengths and grades of any proposed line can be determined with sufficient accuracy to enable a final location to be made.

In carrying on a survey of the character contemplated, it is necessary to run lines of exact levels from station to station, and thus we would have the elevations of points all through the settled portions of the country, and in future operations, in which levelling is a feature, all levels could be referred to a common datum line (sea level for instance), and when railway lines are pushed back into the wooded interior, the physical character of which is but little known, we would then have some definite idea of main watersheds and valleys, to guide future operations, instead of relying, as is at present done, on guess work and hearsay evidence.

Among other benefits to be derived from a survey of this kind are the following: Our extensive coast line both in the Gulf of St. Lawrence, on the Atlantic and Paci-

fic seaboards, and also in our inland waters, has been very roughly determined in many places, and in consequence many disasters happen to shipping, and many valuable lives are lost annually, which would in a great measure be avoided were we in possession of reliable charts of our waters; and one of the first requisites in making the hydrographic surveys, necessary to provide the data or compilation of these charts, is that certain points on the shore should be accurately fixed. It may be mentioned in connection with the hydrographic survey of Georgian Bay, at present being carried on under the direction of Staff-Commander Boulton, R.N., that Commander Boulton stated before the D.L.S. Association, at its last annual meeting, that in making his survey he had not been able to connect his work with any point accurately determined by Canadian authority, but had to use points established by the United States Coast and Geodetic Survey.

On our inland lakes and waters large sums are annually spent in harbour and other improvements, and yet the geographical positions of these harbours and waters are not accurately shown on any map or chart.

A large sum has been spent in building the Murray Canal between Lake Ontario and the Bay of Quinte, but there is no correct chart of the Bay, and a stranger attempting to navigate a deeply laden vessel in its waters would probably meet with disaster. This has happened time and again, and will continue until we have an accurate chart of the Bay, and as has already been said the work of making these charts would be greatly expedited by having points along the shores established by a trigonometrical survey from which to begin the hydrographic survey.

Numerous isolated surveys have been made under various departments of the Government, at points on the Atlantic coast, the Gulf of St. Lawrence, and in the Great lakes; it is also proposed by the Militia Department to make a series of reconnaissance surveys at different points; all these surveys, made, or to be made, give valuable results, but they cannot be considered complete until they are connected. To this end a carefully executed triangulation is necessary.

Again, with the increase in the value of real property, any work having in view the permanent marking of points which would definitely fix the positions of boundaries of real estate is for the public good. In many of the provinces the boundaries of valuable properties are in most cases dependent on the durability of wooden posts, a few marks on trees, or the testimony of a few of the oldest inhabitants, and as a consequence expensive litigation often arises, in fact it may safely be said that the amount annually expended in litigation regarding boundaries would go a long way towards paying for the cost of the trigonometrical survey.

Were the boundaries, especially those of large areas, such as counties, townships, and concessions, accurately defined by a trigonometrical survey, similar to that made by the countries herein referred to, all doubt as to their position would be forever set at rest.

At the present time, throughout the Dominion, every city and many of the towns and villages are looking about for means of obtaining a good water supply or of improving the supply they have.

Gravity being the best method of utilizing a water supply, is generally first sought after, but the information necessary to determine the availability of a supply by this means, can now only be had by expenditure of large sums in surveys, as has been lately seen in Toronto.

Had there been a good topographical map in existence, that expenditure would have been unnecessary.

In drainage work the information derivable from a survey of this kind would be invaluable, and as our agricultural population is waking up to the benefits arising from proper drainage, no time should be lost in giving them this aid. The maps would enable any engineer to determine by a simple calculation the area of any basin to be drained and to know accurately the size of drain necessary, and its proper location, and the survey would do away with all litigation arising from parties claim-

ing that their lands do not lie in the basin to be drained, as a reference to the map would show at a glance the natural drainage outlet for any piece of land.

These maps would also be exceedingly valuable in assisting an equitable assessment of real estate for taxes, and in providing the necessary information required in locating and building public highways, and would save large sums of money which are now expended in finding out where roads should be built; and the sum so saved might be expended in making the roads more solid and permanent.

The information afforded by the maps provided from a survey of this kind, in reference to our inland waters, and the possibility of their utilization for navigation which is becoming every day of more importance, would be of vast benefit to the country.

Many large public works are now being agitated, and will no doubt in the near future be undertaken, as, for instance, the "Ottawa Ship Canal," "The Trent Valley Canal," &c., the possession of good topographical maps would very naturally assist in settling the question of the feasibility of these and many other schemes for the improvement of navigation, &c.

Instances might be cited indefinitely to prove the value, not only to the Government, but to the people at large of a trigonometrical and accompanying detail survey of the kind herein referred to, but it is thought that enough has been said to conclusively show the benefits which would accrue therefrom.

The survey should be undertaken by the Federal Government, as it is preeminently a Dominion work, and we now come to the important point of a basis or scheme for its inception.

In a work of such proportions as a survey of this kind would ultimately assume, it is primarily essential that a well matured and carefully considered scheme be first laid down, upon which to develop the whole; and, being guided by the experience of other countries, it is evident that a primary triangulation is necessary as a ground work for all detail surveys.

For the inception of the work, and that a beginning may be made, it is suggested that the work should be commenced on the St. Lawrence river near Cornwall, where the U.S. Lake survey ended, and be continued down that river to the gulf. The work would first consist of a primary triangulation, with sides of from ten to thirty miles in length, as circumstances permitted, and would then be extended by carrying on a greater or less amount of interior topographical work, levelling, &c.

## COST.

The cost would of course vary with the extent of survey, but it is thought that a sum of, say, fifteen thousand dollars would be sufficient to start the primary triangulation, which is the basis of survey. This amount would cover the cost of two observers, one on each side of the main chain of triangulation, and two station setting parties, and would pay all expenditure of the above for transport and travelling expenses.

Of course a much larger sum than that mentioned could be advantageously employed, but the annual expenditure of this small amount would provide a large quantity of valuable information, and would lay the foundation for more extensive prosecution of the work, when the circumstances warranted it.

The advantage accruing to the country by a geodetic survey would not be confined to the definite material advantages gained in topographical knowledge, and the coast and sounding surveys based upon the triangulation.

An additional and not inconsiderable advantage would be the stimulus given to scientific research. It has been the experience of other countries that men employed on geodetic surveys, having their attention drawn to the numerous branches of science involved, have, by their scientific and mechanical inventions, added greatly to the sum of knowledge in these branches, and indirectly to the material wealth and progress of the countries.

SESSIONAL PAPER No. 145

The Association of Dominion Land Surveyors has long felt that the time had arrived when a trigonometrical survey of the country should be begun, and the question has frequently been discussed at their annual meetings. In 1886 they took action in the matter by preparing a memorial on the subject, and submitted the same to the Hon. the Minister of the Interior; and recognizing the necessity for keeping the matter alive, they appointed this committee, as has already been mentioned, to prepare a memorandum on the subject.

In submitting this memorandum for your consideration, the committee feel the subject is one which should appeal strongly to all who are interested in the welfare of our Dominion, and they think the facts herein contained should be sufficient to show the necessity for a beginning being made towards a geodetic survey of our country.

They earnestly ask you to do anything you can to assist the Association in bringing this matter to the notice of any who are likely to be interested in seeing this much needed work begun, all of which is respectfully submitted.

W. F. KING,
O. J. KLOTZ,
W. S. DREWRY,
E. J. RAINBOTH,
J. S. DENNIS,
} *Committee.*

OTTAWA, April 13, 1888.

*Chief Astronomer to the Deputy Minister of the Interior:*

May 3, 1897.

DEAR MR. SMART,—I inclose herewith a memorandum drawn up some years ago by the Dominion Land Surveyors Association dealing with the question of a trigonometrical survey of the Dominion. This is a matter which has frequently been discussed among the technical officers of the department and which has more than once been brought before the Minister of the Interior, but which has never reached the point of governmental action. I now take the liberty of bringing it up again to ask consideration of it as a matter, as I believe, of importance in the interests of the Dominion.

The advantages of such a survey are pretty clearly set forth in the pamphlet inclosed. In the first place, the extensive use of trigonometrical surveys by civilized nations in itself is a proof of their utility. No doubt the advantages increase with the density of population, and it may be argued that Canada is not in that respect, so favoured as the countries named, and that the expense of such a work would be too great to warrant the Government undertaking it. However, the beginning of a survey and its full completion are two different things. Canada could certainly well afford to undertake the work proposed in the memorandum, the triangulation of the more thickly settled parts of the country along the main waterways.

In the second place the argument in favour of triangulation surveys does not rest solely on the fact that other countries have tried them. There are many very evident advantages of such surveys. These are dealt with in the memorandum, and it is not necessary for me to discuss them here at length.

To be short, a trigonometrical survey means the establishing with accuracy of the absolute positions of a number of points scattered over the country, forming a framework upon which are based, wherever they are needed, detail surveys showing the hills, valleys, rivers, islands, &c., in their true relative positions.

Such surveys of detail have heretofore been made in Canada in many places, both on land and water, but without the connecting framework they lose much of their value as regards permanence, as well as accuracy. As an illustration of the advantages of system, I may cite the Dominion Lands Surveys in the Northwest. The outlines of townships were first laid down with accuracy as controlling lines at a

cost of say fifteen dollars to twenty dollars per mile. Then the interior lines of sections were surveyed at say seven dollars per mile. The more expensive survey of the outlines permitted the cheap surveying of the interior. Had the outlines not been previously laid down, it would have been necessary either to survey the section lines with accuracy and cost equal to that actually applied to the outlines, or to have permitted errors to accumulate, which would speedily have deformed altogether the rectangular form of the surveys, and led to endless confusion of boundaries.

I would suggest that a beginning could be made on the lower St. Lawrence river. The work would become immediately available in assisting the hydrographic surveys of the Marine Department. Attention is now being particularly drawn to the St. Lawrence as a water highway and it seems desirable that an accurate survey should be made of it. The triangulation work would properly come under this department, as it is a matter of land surveying, and not engineering.

The proposed work would include a main triangulation following the course of the hills parallel to the river; a secondary or minor triangulation to establish points of reference on the river bank or elsewhere where needed and astronomical determinations of longitudes of important points, such as Father Point. Magnetic observations would also be made, for the determination of the variation of the compass and information of value as regards the meteorology, tides, and currents would also be obtained. The estimated cost of the first year might be put at $20,000.

Although I have laid more stress here upon the desirability of a survey of the St. Lawrence, I would repeat that the triangulation is not to be considered as a marine or river survey only. It would equally have its use as regards surveys on the land.

W. F. KING,
*Chief Astronomer.*

JAS. A. SMART, Esq.,
Deputy Minister of the Interior.

*The Chief Astronomer to the Hon. Clifford Sifton, Minister of the Interior:*

Hon. CLIFFORD SIFTON,
Minister of the Interior.

June 14, 1899.

SIR,—Having been directed by you to explain the methods and objects of Geodetic surveys, with especial reference to conditions existing in Canada, I have the honour to present the following report:

The question has been raised at the present time by an invitation from the United States Government to join in the measurement of the 98th Meridian. The Royal Society of Canada has also presented a memorial to His Excellency the Governor General in Council on the same subject. In the present report it is proposed to discuss not only this special work, but also the general subject of trigonometrical surveys in Canada.

It may be remarked that this is not altogether a new question; the question of the trigonometrical survey of Canada was discussed many years ago by the Association of Dominion Land Surveyors, who, in 1888, presented a memorial on the subject to the Minister of the Interior. A copy of this memorial is inclosed.

The Association of Ontario Land Surveyors at Toronto, also has lately brought before the Ontario Government the question of a trigonometrical survey of that Province.

A geodetic survey may be defined simply as a survey made with great accuracy. This accuracy is attained by limiting the linear measurements to one or more baselines, from which a chain or net work of triangles is sprung, covering the country to be surveyed. The angles of the triangles are read with the theodolite, and the lengths and directions of the sides are thence computed. Hence, a geodetic survey is often called a triangulation, or trigonometrical survey. The exact levels of the triangula-

tion stations are also determined. The survey is placed in position by means of astronomical observations. Thus a number of points twenty or thirty miles apart are accurately determined as to position and elevation.

When the object of the survey is (as it usually is) the making of an accurate map, the 'filling-in' process follows. An interior net work of smaller or 'secondary' triangles may be based upon the primary system, and the details of the topography placed by means of the plane-table, or otherwise.

The complete survey therefore affords exact data:—

For charts of the coast and inland waters.

For engineering works of all kinds; such as location of highways, railways, canals, drainage works, water supply and estimation of drainage areas therefor, &c.

For military purposes; for geological and other investigations, and for surveys relating to the boundaries of private lands, municipalities, &c., or cadastral surveys.

And affords, generally, to every branch of industry the information needed as to its surroundings without the expense of making a personal tour of inspection.

The memorial of the Royal Society, however, does not contemplate a complete topographic survey, but merely a primary chain along the 98th Meridian, without the filling-in (at the present time) of the topographic details, and their estimate of cost is made accordingly.

As regards the advantages of a primary triangulation alone, it may be said that it affords an accurate basis for the investigations and works indicated above. The work of the engineer and surveyor can then proceed wherever the needs of the population require, and the constant recurrence of duplicated work is avoided. The triangulation, when once made with proper refinement, will, for all time, fill the requirements of every project where accurate information as to position, distance and elevation is required.

That the utility of geodetic surveys is real, and not fictitious, may be seen from the fact that they have been made, and are being made, by almost all civilized countries; all the nations of Europe, Cape Colony, and Natal, New South Wales, India and New Zealand, the United States (and some of the individual states). In India and New Zealand, moreover, the trigonometrical survey has even been a preliminary to the survey of individual holdings of land.

Besides the utilitarian applications of geodetic surveys, results of high scientific value are derived from extended triangulations. The measurement of an 'arc' is the comparison of a distance measured (by triangulation) on the earth's surface with the observed difference of astronomical latitude or longitude of its extremities, thereby giving the earth's curvature in direction, and, by a proper combination of such measures, the dimensions and figure of the earth as a whole.

The determination of the dimensions of the earth is of service in astronomy, for the earth's diameter is the 'yard-stick' with which astronomical distances are measured. The form of the earth's surface also finds a very practical use in surveying. For instance, the Dominion Land Surveys in Manitoba and the Northwest Territories have been systematized by tables (published in the Manual of Instructions to Surveyors) giving the lengths and directions, latitudes, longitudes, &c., of all section lines. To this system is due the accuracy (unequalled for surveys of that class) with which these surveys have been made. We computed these tables from the 'Elements of the figure of the Earth,' deduced by Col. Clarke, R.E., as the result of an abstruse investigation of the data furnished by a large number of geodetic surveys.

An indirect application to other sciences may be suggested as follows: The earth was at one time probably a mass of fluid, having, from its rotation, a symmetrical spheroidal form. During the process of solidification and subsequently contraction it has been deformed by various tidal and other forces, so as to be no longer of symmetrical figure. The exact determination of its present form would help towards an un-

derstanding of the forces which have been acting and those which are now acting upon it, and thereby throw light upon many branches of science, such as geology, terrestrial magnetism and meteorology. Most of the measurements hitherto made have been in the Eastern Hemisphere; for a complete investigation more data is wanted from the Western Hemisphere.

The 98th meridian passes over the greatest extent (north and south) of land in North America. Hence the importance of the work proposed. Moreover, there is special advantage in measurements in high latitudes, and the Canadian part of this arc is correspondingly important.

In considering the advisability of a geodetic survey in Canada, however, account must be taken of the fact that the population is small, and the national wealth is needed for development of resources. Hence more stress must be laid upon the practical than upon the scientific advantages. This is the more allowable because the great triangulation systems in Europe and elsewhere (including the United States) have been designed to serve practical and not theoretical ends. Very little has been done solely for the sake of science, although it has usually been found possible so to shape the plans of triangulation as to secure scientific in addition to the practical results which have been the first consideration.

Looking at the measurement of the 98th meridian from this point of view, it is to be regretted that its practical is not commensurate with its scientific value. Northward from the 49th parallel this meridian runs for one hundred miles or thereabouts over the plains of Manitoba, which have been already surveyed by the Dominion Government with sufficient accuracy for present purposes. Thence it passes between Lakes Manitoba and Winnipeg and across the northern end of the latter. Here the triangulation would be useful for an accurate survey of the lake, which will, no doubt, be needed sooner or later for purposes of navigation. But north of Lake Winnipeg it would run through a country where the possibilities of local utility of such a work are very doubtful.

The cost of the work would be between $100 and $150 per mile, or from $35,000 to $52,500 for the portion south of the north end of Lake Winnipeg, and the smallest rate of expenditure, consistent with efficiency, would be in the neighbourhood of $10,000 per annum. The results to be obtained can hardly be held to justify such expenditure, when so much of the coast and well settled parts of the Dominion is in need of accurate survey.

There is another scheme of triangulation which, while important from a scientific standpoint, is even more so from a utilitarian one, and is therefore worthy of careful consideration. It has been suggested by Dr. Pritchett, Superintendent of the United States Coast and Geodetic Survey. The survey has completed the measurement of an arc over 1,500 miles in length, from Mobile, Alabama, to Calais, Maine. The proposition is that Canada should extend this arc a further distance of about 350 miles to the extremity of Cape Breton. This triangulation would extend along the Bay of Fundy, and would serve as a basis for accurate surveys in New Brunswick and Nova Scotia and Prince Edward Island, as well as for hydrographic surveys of the coasts of these provinces.

It is believed that this survey would so exhibit the practical value of geodetic surveys that the triangulation would afterwards be extended past Prince Edward Island along the south shore of the Gulf of St. Lawrence to meet the survey which will doubtless eventually be made along the St. Lawrence and north of Lake Ontario to and through the western peninsula of the province of Ontario.

In support of the scheme thus roughly outlined, it may be said that the annual expenditure need not be large, the advantages to be secured are many, and the scheme follows a reasonable line of development. The United States Coast and Geodetic Survey has been developed on very similar lines. Beginning on the Atlantic coast, it has gradually been extended over all the coasts of the United States and into the interior as the need of accurate survey became more and more apparent. Besides the geodetic

surveys made by the general government, of which the principal are the coast and lake surveys, topographical surveys have been made by individual states, always based upon the primary triangulation of the coast survey. Thus, for instance, nearly all of New England (except the northern part of Maine) has been covered with a triangulation network; also a large part of the state of New York. The states of New Jersey, Maryland, Ohio, Illinois and many others have made or are making trigonometrical surveys.

In carrying out a survey of this kind in Canada, it is believed that the provinces would find it to their advantage to co-operate, so that, while the Dominion government executed the primary work, the topographical filling in, where necessary, would be done by the province. Many of the useful applications, such as engineering works, boundaries of lands, &c., are properly provincial matters, while others, such as hydrographic surveys, belong to the Dominion, Department of Marine, or other departments.

The cost of producing the 'oblique arc' from Calais to the extremity of Cape Breton by a triangulation chain 25 miles wide is estimated at $35,000, or about $100 the running mile, or $4 the square mile. Of this amount $5,000 is for theodolites and other instruments which would be available afterwards for other work. The remainder of the cost would be spread over three years.

W. F. KING,
*Chief Astronomer.*

## MEMORANDUM OF THE ROYAL SOCIETY OF CANADA, OTTAWA, MAY, 1903.

The committee appointed at the last meeting of the Royal Society for the purpose of ascertaining what action, if any, the government of Canada is willing to take in the direction of extending the triangulation system of the United States Coast and Geodetic Survey into this country as urged by the Royal Society in a memorial presented to the Governor General in Council in the year 1898, and to again urge the importance of the work, have the honour to submit the following report:

In December, 1898, the Royal Society brought to the attention of His Excellency the Governor General in Council a proposal by Dr. Pritchett, at the time superintendent of the United States Coast and Geodetic Survey, to measure an arc along the 98th meridian from Acapulco, Mexico, to the shore of the Arctic Sea in Canada. The measurement of the meridian had been in progress for some time as part of the general survey of the United States; the object of Dr. Pritchett in urging its extension through Canada and Mexico was to provide data for the determination of the figure and dimensions of the earth, and while from this point of view the work would be purely scientific, the Canadian portion of it would also be of great practical utility in forming the basis of a thorough geographical survey for the Dominion. The government of Mexico had announced its readiness to undertake its part of the work; the successful execution of the project as a whole therefore depended entirely on the co-operation of Canada. It was suggested by the Royal Society that a limited grant for this purpose would be regarded as a contribution to aid in the general researches of the nations of the world, while at the same time, it would serve to inaugurate a very much needed work and one of great practical importance to the future of the Dominion.

The answer of the government was that while they fully appreciated the importance of the project from a scientific and practical point of view, they were not in a position then to recommend the co-operation of Canada in the suggested work.

During the five years elapsed since this memorial was presented to His Excellency the Governor-General-in-Council, the work has been more than half completed in the United States and the cost has been reduced to little more than $50 per mile of progress along the axis of the triangulation, this very low figure being due to exceptionally favourable circumstances and furnishing a probable lower limit of cost. In Mexico, the work has been pushed rapidly forward by the Mexican Geodetic Commission. The most difficult part of the triangulation, across the two main chains of the Grand Cordillera, has been completed and connected with the National Observatory at Tacubaya. A preliminary survey for locating the triangles has been made as far as Acapulco on the Pacific coast, towards the south, and Tampico, on the Gulf of Mexico, towards the north. Director Angel Anguiano, under whose skilled guidance the work is being executed, expects to finish the triangulation from Acapulco to Tampico in a little more than a year, leaving only a short interval from Tampico to a point near Matamoros for completing the whole of the work in Mexico.

While considering the advisability of again bringing this matter before the government, it has occurred to your committee that the time has arrived when the larger question of a geodetic survey as a basis for systematic surveys in Canada, should receive earnest consideration. In our memorial of 1898, it was represented that without such a basis, there is no finality in results; the same ground is being surveyed over and over again, as is the case in the Dominion, by the land surveyor, the geologist, the railway or canal engineer, the hydrographer, &c. For every new object a new survey has to be made. The labour and expenditure on these surveys would be considerably reduced and often entirely unnecessary, if we had a systematic triangulation carried out as in other countries.

This fact has long been recognized in Europe where every country has been accurately mapped. Outside of Europe may be cited the United States whose triangulation is well advanced; India which offers a striking instance of extensive and well conducted surveys, the Cape of Good Hope and Natal which have executed a joint triangulation of South Africa; New Zealand, where triangulation has preceded all other surveys. It must not be supposed that there were no objections raised in these countries to the inception of the work; on the contrary it was frequently opposed by those who did not understand its practical value, but their opinions changed after they had been in a position to appreciate its usefulness. Of the survey of South Africa, Mr. David Gill, Her Majesty's astronomer at the Cape, says:—

'The influence of the geodetic survey has made itself felt by raising the whole tone of survey operations in South Africa. Strongly as it was at first opposed and grudgingly as it was maintained, its advantages are now fully acknowledged and by none more warmly than the surveyor generals of the Cape Colony, Natal and Bechuanaland.'

There are few countries, if any, where the expenditure for surveys per capita of population is as large as it is in Canada. The Department of the Interior is subdividing lands in Manitoba, the Northwest Territories and British Columbia, the Geological Survey Department is surveying and exploring in all parts of the Dominion, the Department of Marine and Fisheries is making a hydrographic survey of our navigable waters, a military survey of the country is in course of execution under the direction of the military authorities, the Department of Public Works and the Department of Railways and Canals are also conducting extensive surveys. In these operations, ground already covered by one department is often gone over again by some other department. The same distribution and duplication of work is repeated in each province, where almost every department of the local government and many of the great corporations are making surveys for some purpose or other. Were this great mass of information bound and connected together by a triangulation, it would become possible to take a broad and comprehensive view of great questions affecting the country, instead of considering them only under the few aspects presented by local sur-

veyors. That the practical value of accurate maps is not overestimated by your committee is shown by the experience of the British army in South Africa: millions in money and many valuable lives would probably have been saved, had accurate maps of the country been available. One of the first acts of the British government after the war, and even while it was going on, was to commence an elaborate survey of the country.

The Dominion of Canada, controlling an area surpassed only by that of Russia, but of which the greater portion is still unsurveyed, would be distinctly benefitted by a triangulation as a means for the extension of further surveys. The explorations incidental to the establishment of the triangles would afford an opportunity of collecting information for which any special demand may arise, such as the heights of waterfalls and the volume of water, for determining their commercial value.

While thus advocating a rational basis for the surveys made in Canada, your committee is not blind to the fact that owing to the immense extent of the country and its sparse population, the question presents peculiar difficulties. Were it proposed to organize a geodetic survey on the same lines as in the small, thickly populated European states, the cost would probably be beyond the resources of Canada and the government might well hesitate before undertaking a project of such magnitude. It is believed, however, that a scheme may be devised which, while within the means of Canada, will give to the country, or at least to its most populated parts, the benefits of a geodetic survey. For this purpose, it is respectfully recommended that the government be asked to appoint a commission to collect information and to inquire and report upon the subject. With the material furnished by the Commission, the government will be in a position to decide what is required in the interests of the country and for the development of its resources.

*Chief Astronomer to The Minister of the Interior.*

MAY 5, 1904.

Hon. CLIFFORD SIFTON,

Minister of the Interior.

DEAR MR. SIFTON,—In returning to you the Memorial of the Committee of the Royal Society and other papers concerning the proposed survey of Canada, I wish to be permitted to make a few remarks upon the subject.

The Royal Society suggests that a commission be appointed to inquire into the organization and methods in use in other countries, and to formulate a scheme of survey suitable to the conditions existing in Canada.

I submit that this is not the best way to arrive at the information which the Government needs for intelligent action.

Organization and methods are only of secondary interest in this connection. Methods of survey are well known. They can be found stated very fully both in the reports of survey organizations and in the text books. The principles are simple, slight variations only can be made from certain general lines in their applications, and the variations which it is advisable to make to suit different conditions are only to be discovered in practice, that is, while the survey is being made. The conditions which call for these modifications are Canadian conditions; they are not to be predicted by inquiry into conditions which have existed elsewhere.

Methods, therefore, are for the consideration of the Superintendent of the Survey, after it has been determined to proceed with it, and have only secondary interest to the Government, in deciding whether the survey is to be made.

Similar remarks will apply to the organization.

As for a scheme of triangulation for Canada, all authorities are agreed that the aim should be to extend it over the settled parts of the country. (See the Memorial, also Major Hills' Report). The only question is how much should be done at one time, and where, and what it will cost.

This last, the cost, appears to be the question which is the practical one for the Government to consider and the most important. If this is ascertained, the inquiry as to the extent and locality of the operations is greatly simplified.

I would suggest that the way to arrive at the cost is not to make an academic investigation into what it has cost in other countries, under other conditions, but to make an actual survey here in Canada. A small piece will suffice as a basis upon which estimates may be founded.

Experiment is the best method of obtaining knowledge.

It is necessary to make an exact survey to connect the new Observatory with the old one on Cliff street. I have been intending to do this this spring, and have provided for it in my scheme of work. This survey will have to be made by a triangulation, which will extend to the lower of the Gatineau Hills. There will be an "expansion from a base" to sides of considerable length, approximating to the lengths of the sides of a primary triangulation.

It will be easy and inexpensive to extend from these sides a triangulation along the Ottawa valley a sufficient distance to exhibit the methods, and the cost, of a triangulation.

The cost of the detail which is a separate operation could be ascertained, if desired, in like manner.

Anything done in this way would not be lost, as any general scheme of triangulation must pass through Ottawa. Major Hills in his scheme makes Ottawa the central point for the work in the east.

I may add that another part of Major Hills' scheme is already in progress. I refer to his recommendation that a line of triangulation be carried near the 49th parallel eastward from the Pacific Coast. This is being done in connection with the boundary survey, along the 49th parallel, with the practical purpose of making the measurements along the line, which in that mountainous country cannot well be done in any other way. About 100 miles has already been completed, with an accuracy not far from that of a "primary" or geodetic triangulation. As half the work is done by the United States, Canada is getting a basis for future accurate surveys very cheaply.

In conclusion, I wish to express dissent from Major Hills' statement that the survey must be conducted as a military organization. He bases his opinion on the practice of other countries, and on the supposition that a "rigorous and methodical discipline" is necessary for the successful conduct of survey work.

We have little difficulty in securing obedience to orders on our surveys under civilian control. If the discipline is not 'rigorous' in the military sense, this has an advantage rather than otherwise, in enabling a man to carry out the spirit, rather than the letter of his instructions.

As to the appeal to the precedent afforded by other countries, it must be remembered that in Europe, there are large numbers of engineer officers under pay. The carrying on of these surveys affords them employment in time of peace, and the expense of the work is lessened in the item of salaries.

This condition does not exist in Canada, and Major Hills does not contemplate any saving in salaries, for he estimates for the superintendent and assistant superintendent together, $7,000 as salary. I suppose this means $4,000 for one, and $3,000 for the other. This, I need not point out, is more than the government pays its civilians engaged in superintending surveys.

As conditions in Canada are nearer to those in the United States than to conditions in Europe, comparison should be made with the United States. Major Hills says that there, a 'mixed system' of control is adopted. This is hardly correct. Extensive triangulations are being made there by the Coast and Geodetic Survey, and the

SESSIONAL PAPER No. 145

Geological Survey, both absolutely civilian establishments. Triangulations have also been made by the War Department, but of less extent and importance, with the exception of the Lake Survey, made many years ago. The field work of this survey was I believe largely in the hands of civilians.

W. F. KING,
*Chief Astronomer.*

*Chief Astronomer and Dominion Geographer to the Minister of the Interior:*

July 25, 1904.

Hon. CLIFFORD SIFTON,
Minister of the Interior.

SIR,—Herewith we have the honour to transmit our discussion of Major Hills' report on the survey of Canada.

Our conclusions, based on reasons fully set forth in the appended report, may be briefly stated as follows:

1. Accurate maps are of the greatest value for administrative, military, economic and engineering purposes.

2. While much material for maps has been accumulated in Canada as the result of surveys, the accuracy of the maps is of an inferior order on account of the lack of systematic control by triangulation.

3. Major Hills does not provide for sufficient triangulation to properly control the detail work he suggests, nor is it, as proposed, of sufficient accuracy to meet future requirements.

4. His scheme of detail work involves duplication of existing surveys.

5. Greater advantage would be achieved by carrying on the triangulation on a wider scheme, and discarding for the present the scheme of detail work altogether.

6. The work should be under civilian, not military management.

W. F. KING,
*Chief Astronomer.*

JAS. WHITE,
*Dom. Geographer.*

*Chief Astronomer and Dominion Geographer to the Minister of the Interior:*

July 25, 1904.

SIR,—We, the undersigned, have the honour to report as follows upon the 'Report on the Survey of Canada,' by Major Hills, C.M.G.

We are in thorough accord with him as to the importance and necessity of good maps for administration, military, economic, and engineering purposes. What he says in this respect must, indeed, be considered axiomatic, as also his view that proper maps can only be got as a result of surveys based upon a trigonometrical framework.

Of the necessity of this framework, the uniform practice of all countries which have undertaken systematic construction of maps (including nearly all civilized nations) is proof. So also is the experience of Canada in the attempt to make maps from surveys not systematically connected together.

Major Hills, in his second chapter, 'Existing survey work in Canada', draws attention to some of the difficulties which the cartographer, under existing conditions has to face.

His statement of these is generally correct, though inaccuracies are noticed, generally of a minor character. In one instance, however, to be noticed hereafter, incorrect information has led to a defect in his proposed scheme of survey. We think, also, that too much is made in the Memorial of the Royal Society of Canada, which he

quotes, of the supposed duplication of work by different departments of the public service.

In his general conclusion that the proper remedy for existing difficulties is a systematic survey and that such survey should be initiated without delay we beg to express our concurrence, though we do not agree with him as to the precise nature of that systematic survey, nor in his dictum that the survey should be under military control.

We now proceed to consider his recommendations as to

(1). Organization and plan of operations.
(2). The question of military or civil control.

### ORGANIZATION AND PLANS.

Major Hills provides in his scheme for 'a good backbone of secondary triangulation, filled in with tertiary work'. This word 'backbone' seems to indicate that he intends to confine the triangulation to narrow strips or chains merely (10 to 30 miles wide he says in the foot note of page 13). His maps at the end of the report bear out this construction of his words.

Now this is, in our view, quite insufficient. A 'network' covering approximately the area which is to be surveyed in detail is necessary.

On his map No. 1, he shows 'detail' of considerable extent supported on a narrow strip of 'secondary' triangulation. In some places, as for instance on the Vermont border, this detail extends as much as sixty miles or more beyond the limits of the triangulation.

By this scheme, the detail survey is extended quite beyond control. The advantage of triangulation methods is lost, and his proposal is in effect to continue the methods practiced heretofore, and to add one more to the surveys which he considers useless for the purpose of accurate maps.

That we have not misunderstood his proposal, and that it really means the non-performance of any triangulation except in certain narrow strips, from Detroit to the Gulf of St. Lawrence, from Ottawa to Sault Ste. Marie, &c., is shown by his map No. 2, which shows the 'ultimate development of triangulation', and which does not widen the areas of secondary triangulation shown on Map No. 1.

Our view is that a triangulation survey should consist of:

1. A chain of triangulation to form a 'backbone'. This chain would in Ontario and Quebec follow generally the same course as his chain. It should, however, be performed with a higher degree of accuracy than he suggests. Instead of 'secondary' it should be of 'primary' character, though it need not be of the extreme precision of the best geodetic work.

2. Then this chain would be expanded, when required, into a network of 'secondary' triangles, covering the area to be accurately mapped.

This method, we believe to be the only satisfactory one, having regard not only to present but also to probable future requirements. To base the surveys of such an extensive region as we have to deal with upon triangulation of an inferior order, without providing for the stiff 'backbone' which a primary triangulation alone can afford, would lead, when the work is extended to any considerable distance on either side, to accumulated errors of great amount. The result would be that the work would sometime or other have to be done over again. It is surely better to do the work on proper principles from the beginning.

Major Hills' scheme then is defective:

1. In that he has too much detail in proportion to the triangulation over the region that he proposes to survey in detail, and

2. In that the triangulation he proposes is not accurate enough to extend from in the future.

We have further to say that, in our opinion, the survey of detail is not needed at the present time. The operation should be confined to triangulation.

There is plenty of information extant for the construction of maps, derived from the surveys of the Dominion and Provincial Governments. What is needed most is control of errors.

The only control at present consists in the latitudes and longitudes which have been astronomically determined at certain points. These points are too far apart, and to multiply them so as to give control comparable to that of a triangulation would be too costly.

To make full use of the topographical information which has been accumulated, control points twenty miles apart, or thereabouts, are required. These should be established by triangulation. To them the existing detail surveys would be connected.

Then wherever the existing work was found insufficient, or inaccurate, it would be an easy matter to supplement or replace it, by work of full detail, but this should be postponed until its necessity is proved. To do otherwise would almost certainly involve rejection of former work of as good quality as the new, a duplication of work more inexcusable than that spoken of by the Royal Society. With her immense unsurveyed areas Canada cannot afford to risk this.

It is further to be observed that accurate triangulation is needed for one of the principal objects of the survey, the acquiring of information of engineering value in relation to railway location, water supply and drainage question, &c. For these a higher degree of accuracy is called for than for maps of the scale proposed. Major Hills' scheme does not appear calculated to achieve the accuracy required.

We therefore think that attention should first be directed to the triangulation and that this should be extended rapidly over the country. No detail work should be provided for until existing surveys, as checked and controlled by the triangulation, are proved insufficient. Major Hills proposes an annual expenditure of $75,000, of which from $15,000 to $16,000 is for the triangulation. If our opinion is correct, this last sum would be the only useful part of the expenditure. We leave out the salaries at headquarters, as we believe that the work can be conducted under existing departmental organization.

Major Hills estimates that the amount of triangulation he could get for the money would be 250 linear miles per annum. This is $60 to $64 per linear mile, or $3 to $3.20 per square mile, if the triangulation were 20 miles in width.

We think this somewhat high and that the cost of a party's work for one season might be reduced by twenty per cent without lessening the amount of work which could be done. The amount of work for a season, however, will vary according to the favourable character, or otherwise, of the country passed over, and so cannot be very accurately predicted.

As to the selection of routes for the main chains of triangulation, we would suggest following pretty closely Major Hills' scheme in Ontario and Quebec, that is, from Detroit to the Gulf of St. Lawrence, and, subsequently, from Ottawa to Sault Ste. Marie, with possibly a connecting chain along the western face of the province of Ontario (east of Lake Huron).

In the Maritime Provinces there should be a chain alongside the Bay of Fundy, which would be a continuation of the 'oblique arc,' which has been measured by the United States Coast and Geodetic Survey from the Gulf of Mexico to the New Brunswick border. Major Hills, under the impression that the work of the Geological survey there was of special accuracy, provides for no triangulation in the Maritime Provinces. With regard to this he has been misinformed; the surveys there are in no more satisfactory state than they are in the other provinces.

Major Hills proposed transcontinental line of triangulation along the 49th parallel is now in part in actual progress, in the course of the operations of the International Boundary Commission. It is therefore unnecessary to provide for it as a part of the scheme now under discussion.

The triangulation of the 98th meridian (through Manitoba) is worthy of consideration from the scientific aspect, as a part of the great work now being done by the United States and Mexico, but having little importance from the topographical point of view, compared with the more pressing work in the eastern provinces, may be dismissed for the present.

## THE QUESTION OF MILITARY OR CIVIL CONTROL.

Major Hills argues for military control on two grounds—precedent and essential superiority.

1. As regards precedent, he says, 'practically all great national surveys have been carried out under military direction.' He refers to the example of 'Great Britain, France, Italy, British India, South Africa (in future), and many other countries.'

For a fair estimation of the value of these precedents, instances on the other side should be considered. Without going into an exhaustive discussion of this point, it may be sufficient to call attention to the work of the 'Geodetic Institute,' founded in Prussia in 1869, which is under civilian control. It has charge of the primary triangulation as well as of the international triangulation for Europe. It stands in the very first rank in geodesy, the world over. The example of other German states might also be cited, such as Hanover, Bavaria Nassau, Baden and Wurtemburg.

Thus even in Europe military control is not without its exceptions. In discussing a subject of a scientific nature, or at least having scientific bearings, Germany surely deserves consideration.

In fact, military control in Europe has the simple explanation that where a large standing army exists, numerous officers of engineering corps are unemployed in time of peace, and their services can be utilized in national undertakings with little extra expense for salaries. The value which maps have for military purposes is also first perceived, and this naturally throws the surveys needed for their construction into the hands of the engineer officers. When modern requirements, however, show the desirability of accurate surveys for economic, engineering purposes, &c., we find a tendency to replace military men by civilians. It is becoming more and more generally recognized that a survey is a scientific operation, and application of a science, geodesy, and must be carried on as such by specialists, trained men working under scientific supervision. It is not an avocation for men whose education and ambitions point in another direction.

Major Hills admits, as an exception to his list of precedents, the case of the United States. This exception breaks all the force of his argument, for conditions in the United States are most nearly like our own.

The reasons given above for the employment of military men in these surveys in Europe do not apply in the United States. Accordingly we find there the surveys carried on under civilian management. Neither do these reasons apply to Canada. We have therefore against the practice in the United States, and the practice heretofore in Canada, in very extensive surveys, nothing but the citing of bare precedents, themselves not universal.

Major Hills, however, says that in the United States a 'mixed system' of control is adopted. This is incorrect.

The topographic surveys of the United States are in the hands of the Geological Survey, under exclusively civilian control. The work of this survey is very similar to that proposed for Canada.

The United States Coast and Geodetic Survey makes triangulation and hydrographic surveys along the coast, and also carries on extensive geodetic surveys in the interior. The accuracy and systematic character of its work receives world-wide recognition, yet it is wholly under civilian management.

The two bureaus mentioned are among the largest in the world, each expending over $1,000,000 per annum.

Surveys by the United States War Department are now a thing of the past.

Major Hills speaks of the geodetic survey of South Africa, (which has been carried on by Sir David Gill, H. M. Astronomer) as having been a 'disastrous failure.' The difficulties which this survey encountered and which ultimately led to the change in control, were not due to the inefficiency of civilian management, but to financial difficulties arising from a peculiar arrangement by which two independent colonies, Natal and Cape Colony, were to share the expense equally, and consequently demanded an equal division of the work between them, irrespective of the interests of the survey itself.

2. Major Hills further says, 'for the successful conduct of survey work, a rigorous and methodical routine, combined with a quasi-military discipline is absolutely necessary.'

From this dictum we emphatically dissent. The essential point in military discipline, in which it differs from what may be called business discipline is unquestioning obedience to orders, regardless of results.

We have no hesitation in saying that the less such a principle enters into the relations between headquarters and the chief of a field survey party, or between the latter and the men under him the better. In this country, whether due to education or some other cause, the best work is to be got out of men in a different way.

The ordinary 'business' discipline has proved sufficient in Canada in the execution of most extensive surveys, Dominion and Provincial Land Surveys, the Geological Survey, railway surveys, &c. If military discipline is 'absolutely necessary' for the proposed survey of Canada it must be necessary also for these. If so, it should be applied to them. Yet these surveys have been and are being carried on successfully without it. Here in Canada is a precedent against military control vastly stronger than all the precedents Major Hills can cite from the Old World

W. F. KING,
*Chief Astronomer.*

JAS. WHITE,
*Geographer.*

*Acting Deputy Minister of Militia and Defence to the Deputy Minister of the Interior:*

OTTAWA, April 15, 1905.

THE DEPUTY MINISTER OF THE INTERIOR.

SIR,—I am desired by the Hon. the Minister of Militia and Defence to forward, for the information of the Hon. Minister of the Interior, the inclosed memorandum which has been submitted to Sir Frederick Borden by the Chief of the General Staff.

The Minister of Militia is strongly impressed with the importance of the subject considered in that memorandum, and would feel greatly obliged if the Minister of the Interior could see his way to taking action in the direction indicated by Brigadier General Lake, in the concluding paragraph of his memorandum.

E. F. JARVIS,
*Acting Deputy Minister of Militia and Defence.*

*Brigadier General Lake to the Minister of Militia and Defence:*

OTTAWA, April 14, 1905.

THE HONOURABLE,
THE MINISTER OF MILITIA AND DEFENCE,
Ottawa.

1. I have already brought to your notice the great disadvantage under which the Militia force of Canada would labour in consequence of the non-existence of proper maps of the country, in the event of that force unhappily being required to repel invasion.

2. That an army should not be able to command the use of good maps of its own country is not only a reflection upon the progress of the nation, but is a defect which directly tends to invite defeat, more especially in a case such as ours where a Canadian force would have to face superior numbers and would need every advantage it could get from science to enable it to cope with them.

3. Yet it may with truth be said that, with the exception of a survey of a portion of the Niagara peninsula and of one or two other small areas, there is not in existence a map of any part of Canada good enough for military purposes.

4. Canada is probably the only civilized country in the world which does not possess or endeavour to produce a reliable survey representing the topographical features of the main roads within, at least, the settled portions of its area.

5. I know no Canadian map which attempts to delineate the contours of the ground in the manner adopted by the Ordnance Surveys of European countries and of the United States.

6. The main reason for this is that any survey, to be accurate, must be based upon the exact determination—by astronomical observation and triangulation—of certain selected points within its area, on which the actual surveyors can 'close,' *i.e.*, verify their work. These hardly exist in Canada.

7. By your direction the officers employed by the Militia Department have for the last few years been endeavouring to supply the requirements of the country for defence purposes, by surveying those portions of the country which are of most importance from a military point of view. But progress has been slow, not only because the surveyors available have been few, but, largely, because even they have been seriously retarded by the absence of the accurately determined points alluded to in the preceding paragraph.

8. Had a reasonable number of such points been already determined, their rate of work, as well as its accuracy would have been enormously increased.

9. Such work as has been accomplished cannot be utilized to its full extent without having such points to connect up with.

10. In fact, what is known as a primary triangulation is absolutely necessary in order even to inaugurate such a survey as has been referred to. It is a preliminary necessity for all accurate surveys.

11. That a reliable topographical survey of the more settled parts of Canada—one which showed the natural features, including the contours of the ground, as well as the main roadways—would repay the country its cost within a very few years is a thesis which admits of no question. This, however, is, apart from the military point of view, of course a matter for the government to decide.

12. But in the meantime the military surveyors are urgently in need of more of the 'fixed points' referred to in paragraph 6 above.

13. The Chief Astronomer of the Department of the Interior, has already fixed the position of a small number of such points. He has courteously placed the result of his work at the disposal of the Intelligence Division.

14. I gather from this that he has the necessary instruments and the trained observers at his disposal, and that he could, if authorized, carry out a primary triangulation, such as that referred to, inexpensively and expeditiously.

15. I venture to suggest that the Minister of the Interior be made acquainted with the importance which the Militia Department attaches to this subject, and that he be requested to lend his powerful assistance to further the object in view, by giving his Chief Astronomer necessary authority.

P. LAKE,
*Brigadier General, Chief of the General Staff.*

*Chief Astronomer to the Deputy Minister of the Interior:*

May 2, 1905.

W. W. CORY, ESQ.,
Deputy Minister of the Interior.

MEMORANDUM,—The subject of General Lake's memorandum is, I submit, of great importance. A trigonometrical survey of Canada, at least of the well settled parts, would be of the utmost value for administrative, engineering and military purposes, its function being to furnish for the detailed surveys for these purposes an accurate basis, without which the requisite precision cannot be secured.

It does not appear necessary here to enlarge upon the necessity of such a survey, as I have already reported on the matter a number of times to the Minister and Deputy Minister. General Lake forcibly sets forth the military side of the question: from other points of view, especially the engineering and economic, the importance of the survey may likewise be strongly represented.

I respectfully submit that the survey is one which will have to be made some time or other and that an early beginning at the triangulation will be the best economy. I ask, therefore, to be authorized to commence work in the neighbourhood of Ottawa, expanding from a triangulation which I have now in hand connecting the old observatory on Cliff street with the new.

This triangulation is being paid for out of the appropriation for the astronomical work, which, however, is not sufficient for extended work in this line. I estimate that a sum of $15,000 may be with advantage expended on the work during the coming fiscal year, and beg to recommend that this amount be provided in the supplementary estimates for the year 1905-6.

W. F. KING,
*Chief Astronomer.*

*Major-General Lake's Memorandum to the Minister of Militia and Defence.*

The Honourable the Minister
of Militia and Defence,
Topographic Survey of Canada.

1. Referring to our recent conversation on the subject, I have the honour to submit for your consideration, that the time has now come when a systematic and uniform topographical survey of Canada should be undertaken, and when, also, the various departments of the Dominion government, who are concerned with survey questions, should consider how they can best co-operate with each other in that work.

2. At the present time the following Dominion Government departments are concerned with surveying questions:—

(*a*) The Department of the Interior, which besides the surveys executed under the Surveyor-General has responsibility for the geological survey of Canada.

(*b*) The Department of Militia and Defence.

(*c*) The Department of Railways and Canals.

(*d*) The Department of Marine and Fisheries, and to some extent

(*e*) The Post Office Department.

These are in addition to various Provincial government departments. Yet there is no general survey system, common to all departments, in existence. Nor is there

with one or two local exceptions in the west, any reliable topographical map of Canada.

3. It should be explained that a topographical map is one which records correctly in graphic form the artificial and natural features constituting the physical conformation of the country, *i.e.* which shows the height and shape of mountains and rising ground, the position and width of rivers and lakes, the nature and extent of forests and swamps, and gives information concerning villages, roads, railways, canals, bridges, farms, docks, &c.

4. For military purposes, a reliable topographical map is absolutely essential. To the general in command of troops in the field such a map is invaluable. To have one or to be without one may well mean the difference between victory and defeat. Hence the interest of the Militia Department in the question of an accurate topographical survey. But it should be clearly understood that there is no essential difference between a good map made for civil and one made for military purposes.

5. The Survey Branch of the Military Department has been endeavouring in a small way, to meet this want so far as the militarily more important portions of the country are concerned, and gratefully acknowledges the cordial assistance which it has received from the survey officials of all departments, who no doubt give their help equally readily to other departments. Yet I am certain that the many men of ability among these officials will be the first to acknowledge that the different departments are working on separate systems, practically without co-operation with each other, or collaboration of results. From this want of combined effort, there must necessarily result inadequate return for the money spent, in fact waste of power.

6. As is well known, Dominion and Provincial government departments (apart from the Department of Marine and Fisheries, which has its own special maps) spend considerable sums annually for 'geological' and 'land' or 'cadastral' surveys, whose main functions are the production of maps showing geological formations or of large scale property plans, showing boundaries, areas of townships, properties, roads, &c.

7. It is not possible to compile correct topographical maps from the 'geological,' 'land,' or 'cadastral' surveys, as they do not profess to show accurately natural features (they do not usually show hills at all) and are not based on an accurate framework of 'triangulation,' the necessity and nature of which is explained in the appendix to this letter.

8. A systematic topographical survey of the whole country would incidentally provide the means for the co-ordination of all existing survey work, because in carrying it out, it would first be necessary to make a framework of 'triangulation' all over that portion of the country which is to be surveyed, in order to accurately fix the position of a number of well marked points. These points are known as 'trigonometrical' stations and would generally be on the top of hills or rising ground and on an average of from one to five miles apart all over the country. The exact position and height of these trigonometrical stations would be known and they would serve as useful fixed points to which government, provincial or private surveys of all kinds could be referred, or 'tied.' It is owing to the absence of such framework of trigonometrical stations that the large amount of survey work going on all over the Dominion cannot be co-ordinated and work is often duplicated.

9. The commercial value of co-operation among the existing survey departments to undertake a systematic topographical survey of the country is evident when it is considered that it is the physical conformation of the country which decides where railways, canals and roads are to run, and that under existing conditions nearly every newly projected railway, canal or land settlement project has to make its own separate surveys, which being private property, are not generally available for the subsequent use of other persons.

It is not suggested that new railways and canals could dispense with special detailed surveys of their own, but much of the expense of preliminary surveys to

decide the approximate or possible locations of the routes or lines in the first instance would be saved if topographical maps of the country were available.

10. There can, therefore, be no doubt as to the need and value of a systematic topographical survey of the country.

It remains to be considered how this work should be undertaken.

11. Economy and uniformity in the topographical mapping of the country can evidently be best assured by the creation of some central organization to undertake the work.

12. Such an organization would in no way interfere, but on the contrary should greatly develop the work of the existing survey departments. It would, however, depend largely on the assistance of these departments, as the work would require the services of the best surveyors in the country.

13. The question as to the method of procedure to carry out a systematic topographical survey of the country is a technical one and can best be settled by experts.

14. My own opinion of the matter is that (a) A general statement of the views (as to the desirability and method of procedure of such a survey) should be obtained from each government department engaged in survey work. Then, if these views are favourable to the general execution of the work; (b) An interdepartmental conference presided over by some unbiassed expert might be assembled to formulate a scheme in accordance with the views of all concerned and report on the best method of forming a Central Topographical Survey Department to undertake the mapping of the whole country.

15. If this is not at once feasible, I suggest the following procedure which would not interfere with the ultimate establishment of a Central Department, as proposed above.

The execution of the 'primary' and 'secondary' triangulation (as explained in the attached appendix) should be entrusted to the Department of the Interior, which already has at its disposal the services of expert and scientific observers capable of carrying out the work with the required accuracy. They might first carry out the triangulation of that part of the country where their work can best meet the requirements of the departments interested. They should 'tie on' their triangulation points to those fixed by the United States Coast, Geodetic and Lake Surveys.

The points so fixed by the Department of the Interior would be of great value in co-ordinating the survey work of other departments in the neighbourhood of such points.

16. The Militia Department is probably the only one which at present regularly carries out topographical surveying, including contouring, actually on the ground, a distinction being made between this method and the photographic method employed *e. g.* in British Columbia.

It could, therefore, at once make use of the 'primary' and 'secondary' triangulation made by the Department of the Interior and proceed to divide this up into 'tertiary' triangulation from which topographical maps of the areas over which the triangulation extends could be made, which would, of course, be at the service of other departments, should they require them in addition to their own surveys.

17. Other departments would adopt a similar course or not as might seem to them best, but they would be placed in possession of the results of the work of the Interior and Militia Departments and would continue to carry on the special surveys needed for their own requirements as at present.

18. Finally, in order to secure co-operation between the various departments concerned, and to avoid overlapping of work, an interdepartmental committee should be formed, composed of the heads of the various survey branches, which should meet at stated intervals. At its meeting, the members would communicate to each other details as to work in progress and work in contemplation, and could thus arrange for mutual assistance and the avoidance of overlap. A very important question for them to settle would be the adoption of a uniform system for all topographical work executed.

19. It is not possible in a letter to give more than a general outline of such a large undertaking, which can only be settled in detail by personal discussion.

The appendix describes in general terms the principles upon which the general survey of a large country is usually carried out.

## APPENDIX.

Outline of the system generally adopted for executing the topographical survey of a settled country.

1. The methods adopted for carrying out a topographic survey of the country may be said to be practically the same as regards general arrangements in all countries which aim at possessing reliable maps of their own territory. Such countries include almost all civilized nations except Turkey, the South American States and Canada.

2. The first step is to cover the face of the whole country, or at any rate of such portion of it as it is desired to survey accurately, with a number of carefully determined points the exact positions of which are fixed with the utmost accuracy. The intention of this is, that these points shall furnish a number of fixed stations to which the individual surveyor can refer his work, and by which he can check it, so that the chances of serious errors, and especially of accumulated errors, are practically removed. They thus form a framework or skeleton upon which the accuracy of the detail depends.

3. The determination of the exact position of these fixed points is effected by:

(a) Triangulation; or

(b) Astronomical observations; or

(c) Combinations of these two.

Of these, triangulation is the most accurate and is to be preferred, though astronomical observation is often, in certain descriptions of country, usefully employed to replace or supplement it.

Triangulation is merely the application of the well known principle that when the length of one side of a triangle is known, and the angles at either end, the length and position of the other sides and of their intersecting point can be accurately determined.

4. Hence the first step is to measure with the greatest possible care and accuracy, on suitable ground, a line to serve as base for the first triangle. This base being measured and the position of its ends fixed, the next step is to measure from each end the angle between that base and a third selected point which is to form the apex of the triangle. The first triangle is thus accurately determined.

5. Using the three sides of the triangle thus fixed as bases in their turn, other triangles are built up on them, and on these again others, until the whole country is covered with a network of imaginary triangles, the intersecting points of whose sides are thus minutely determined. The result is called the Primary or Principal Triangulation.

Its accuracy is generally checked at the completion of the process by actual measurement of a side of one of the final triangles and the comparison of that measurement with its computed length.

In carrying out this Primary Triangulation every possible precaution is observed and the computations are most exact and minute. The sides of the different primary triangles vary according to circumstances but in the United Kingdom and India they average something over 30 miles.

6. The Primary Triangulation being completed, the next step is to break up these large triangles into smaller ones, having sides of about half their length. This is called the Secondary Triangulation. This again is usually followed by Tertiary Triangulation or the breaking up of these secondary triangles into still smaller ones, with sides having the length of from one to five miles. It is within these last triangles that the regular topographical surveyors work.

7. It does not necessarily follow that the whole process is adopted exactly as above described, but the main object aimed at is to obtain a network of accurately measured small or tertiary triangles upon which the surveyor can base his work.

It is often of advantage to fix some of the important points by astronomical observation, which may also be used concurrently with the work of triangulation, but the result is practically the same.

The ends of the base and all the other points determined, are carefully marked on the ground by stone posts or other monuments.

8. The necessary number of intersecting points or 'stations' having thus been finally determined, the individual surveyor marks the corresponding position of such of them as are suitable for his area on the paper stretched on his plane table, according to the scale of his map, and proceeds to fill in the detail, knowing that the existence of these fixed points will prevent the accumulation of any serious error.

9. It is to be remarked that it is not necessary for practical purposes for the whole of the triangulation network to be completed before topographical work can begin. It is sufficient if one or two of the main triangles, near the area which it is desired to survey first, can be fixed. The secondary or tertiary triangulation can then proceed without the delay which would otherwise be incurred, while the accuracy of the topographical work will probably be sufficiently good to render it unnecessary to resurvey the area after the triangulation is completed, until in course of time the progress of settlement makes a revision of the whole necessary.

February 20, 1906.

## MEMORANDUM *re* TOPOGRAPHICAL SURVEY OF CANADA.

Major General Lake's report, transmitted by Sir Frederick Borden, represents the need of a topographical survey of Canada and asks the co-operation of other Departments. He suggests that the trigonometrical survey be undertaken by the Department of the Interior, the topography to be the share of the Department of Militia and Defence. Sir Frederick thinks that the report is worthy of careful attention and asks that the matter may be taken up for serious consideration at an early date.

The object of a trigonometrical or geodetic survey is to establish over the surface of a country a number of reference points fixed with great precision and to which all local surveys can be connected. The need of a geodetic and topographical survey of Canada has frequently been brought to the attention of the Government. The objects to be served and the advantages to be derived therefrom are fully set forth in Major General Lake's memorandum, and will be concurred in by every one conversant with the subject. So far, the Government has taken no action to carry out the many suggestions made in that direction, the question of cost being the principal obstacle. This question and the kind of survey to be made require careful consideration.

The latest scheme is that proposed by Major E. H. Hills, C.M.G., an expert sent here by the War Office to study and report upon the question. His estimate of cost varies from ten to twenty-three millions. Major Hills was not conversant with the conditions ruling in Canada and his figures in consequence are too low; the surveys which he proposes would actually cost several times the sums quoted. The Government will probably be of the opinion that the time has not yet come when Canada can undertake a scheme of such magnitude and that there are more pressing needs to be attended to.

Major General Lake's proposal is that a general statement of the views of each government department be obtained; then, if these views are favourable to the general execution of the work, he suggests an Interdepartmental Conference presided over by some unbiassed expert, to formulate a scheme in accordance with the views of all concerned.

The men who are qualified to act on an Interdepartmental Conference are all busy men, and the exacting nature of their duties leaves them very little time for rest or leisure. My experience of Interdepartmental Conferences is, that, unless a delegate has some material advantage to be promoted by the recommendations of the Conference, he shows little inclination to sacrifice his spare time in working for the Conference. As he receives no remuneration for this work, his attitude should not cause any surprise.

The questions to be submitted to the Conference are not such as can be settled by a short informal talk; they require careful and earnest study, the collection of statistics and the investigation of the processes, methods, and results of other countries. This is beyond the scope of an Interdepartmental Conference. A much better proposal has been submitted by the Royal Society of Canada; it is to appoint a Commission to investigate and ascertain what is best adapted to the needs and resources of Canada. The members of the Commission should be selected among the most eminent engineers in Canada and the majority should be taken outside of the Civil Service. When the facts have been collected and put in proper shape by the Commission and a definite scheme submitted, the Government will be in a position to act.

It is recommended that in reply to his letter, Sir Frederick be informed that while the Minister fully concurs in his views of the matter and is ready to co-operate so soon as a practical scheme is found, he (the Minister) does not see how the long investigations and researches necessary for reaching a definite conclusion can be carried out by an Interdepartmental Conference and that he is inclined to believe that a special Commission consisting of the most eminent engineers in Canada might be preferable. Of course, the Commission will cost something while the Conference will cost nothing, but in a matter involving the expenditure of millions of dollars, the best advice is the cheapest, whatever may be its cost.

E. DEVILLE,
*Surveyor-General.*

*The Surveyor General to the Deputy Minister of the Interior.*

OTTAWA, April 17, 1906.

MEMORANDUM,—The Canadian Society of Civil Engineers recommend that the Government appoint a small commission of experts, of whom at least a majority should not be connected with the existing Survey Departments, and that this commission be authorized and instructed to obtain such information both in Canada and abroad as will enable it to report upon a satisfactory scheme for the co-ordination of the various surveys now being conducted by the Dominion Government, and the adoption of such methods as will secure permanent records both in the field and in the office; these recommendations to be such as will adapt themselves to the establishment of a trigonometric survey of the country. Further, that the commission be instructed to outline the best methods of inaugurating a geodetic survey for Canada in accordance with the foregoing considerations.

Such a commission has already been urged by the Royal Society of Canada and I reported upon it to the Minister on December 29, 1903. Copy of the report is herewith. It was observed that the surveys contemplated were an enormous undertaking; before coming to a decision, it would be wise to thoroughly investigate the subject and therefore the suggestion of the Royal Society that a commission be appointed for the purpose seemed to be timely.

The same subject was brought up again by Major General Lake in a report transmitted by Sir Frederick Borden on January 24, 1906. His solution was an interdepartmental conference. In reporting upon this proposal, I pointed out that this was not a matter that could be settled by an informal talk between some departmental officers; it required careful and steady work, the collection of statistics and the study of the processes, methods and results of other countries. The lowest estimates of the

cost of the undertaking were ten and twenty-three millions of dollars and the actual cost would be several times as much; before plunging into such expenditure, the whole subject should be thoroughly investigated. That could only be done by an independent commission consisting of the most eminent engineers of Canada and to which should be given every facility for collecting information. Copy of my report is herewith.

The scope of the commission now proposed by the Canadian Society of Civil Engineers is practically what I recommended in December, 1903, but they precise more than I did some of the questions to be looked into. They want a method to be worked out whereby all records shall be made accessible and all survey monuments built and referenced so as to be permanently available. In the development of such a method, the necessity for a general topographical and geodetic survey for the whole Dominion is to be borne in mind as a work which will ultimately be necessary for unifying the various surveys of the country.

The matters to be investigated by the commission are of great public interest. If a practical scheme can be devised to accomplish what is proposed, its adoption will result in the increased accuracy and usefulness of the surveys and will be of great benefit to Canada. If on the other hand, it is found that the full realization of the scheme is impossible or beyond the resources of Canada, the investigation will have served at least to prevent the waste of public money in abortive attempts to carry out impracticable schemes. In any event, the work of the commission will be of practical and immediate use.

The memorandum from the Secretary of the Society is returned herewith.

E. DEVILLE,
*Surveyor General.*

December 29, 1903.

MEMORANDUM *re* TRIGONOMETRICAL SURVEY.

A trigonometrical survey is a survey made for the purpose of establishing a number of reference points over the surface of a country and of determining their relative positions with great precision. It is called 'trigonometrical' because it is performed by the application of the rules of trigonometry.

In making ordinary local surveys, it is impossible to avoid slight errors which, although individually of small importance, may by accumulating, reach large dimensions. It follows that whenever an attempt is made to join two of these surveys, it is almost invariably the case that they are found not to fit together; they overlap or leave gaps between them or their directions do not agree. The discrepancies are small or large, according to the care and skill of the surveyor but in either case, the surveys must be distorted, compressing them in one direction and expanding them in another, before they are made to fit. By so doing, new errors are introduced so that the joint survey is more inaccurate than each of the two surveys. The greater the number of local surveys joined together the worse becomes the result and the errors may reach very large proportions. The object of the reference points of the trigonometrical survey is to prevent this accumulation of errors. Each local survey is adjusted upon the reference points situated within the area surveyed; its dimensions, directions, and position thus become accurate and it is found to fit exactly with any other local survey similarly adjusted upon other reference points.

The relative positions of the reference points are determined by the formation, through imaginary lines drawn between the points, of a network of triangles; hence the name of 'triangulation' used as a synonym of 'trigonometrical survey.' (See plate 14, showing trigonometrical survey of India, in progress.) The three angles of every triangle and one side of one of the triangles called 'base,' are carefully measured;

from these measurements all the sides of all the triangles are computed. The heights above sea level are deduced from angles of elevation or depression and the directions of the sides from astronomical observations at some of the points. The reference points, being the vertices of the triangles at which the angles are observed, are called 'triangulation stations or points.' Each is perpetuated by a cut stone of suitable dimensions sunk in the ground and the exact point is indicated by cross lines cut on a brass or copper plug imbedded in the stone. The triangulation stations are placed as far apart as it is possible to see them; in a flat country, the distance does not exceed twenty miles, while in a mountainous country, it is often more than a hundred miles.

The base is located on a flat piece of ground; it varies in length from two to ten miles according to local conditions. The distance between the ends of the base is measured by means of a steel bar surrounded by melting ice, for keeping its length constant. (See plates 1 and 2.) or by means of duplex bars, steel and brass, (plates 3, 4 and 5) or by other accurate means. Such measurements have been made with an error not exceeding one inch in a hundred miles but the opinion has been gaining ground that this degree of precision is unnecessary because it is lost in the other part of the operations, that of measuring angles. An accuracy of one foot per hundred miles appears sufficient and that has recently been obtained by the use of long tapes made of a new alloy of nickel and steel (plate 6); the operation is far less expensive than with other apparatus. The small base is connected with the main triangles by a series of triangles of increasing size (see plate 13) showing how a triangle side 150 miles long is deduced from a 7 mile base.

The angles at a triangulation station are observed with a special theodolite (plate 12) set exactly over the cross of the brass plug indicating the station. In a flat country, the theodolite must be raised over the intervening woods or other obstacles so that the next stations may be seen. In India this has been done by erecting masonry towers 50 feet and upwards in height. In America scaffolding is preferred, as being less expensive (plates 7 and 8). In a mountainous region, the stations are located on high mountains, dominating the country (plates 9, 10 and 11). The high towers or scaffolds are not needed and the stations may be placed at enormous distances, often exceeding 150 miles. The longest triangle side that has ever been measured is in the United States, between Uncompahgre peak, Colorado, (plate 10) and Mt. Ellen, Utah; its length is 183 miles. At such distances, special means must be resorted to in order to render the stations visible. The device most frequently employed is the 'heliotrope,' a mirror four or five inches square, reflecting the sun's rays towards the observer; the instrument is shown on the left of plate 11. Powerful lights are also employed at night, as for the triangles connecting Spain and Algeria over the Mediterranean. One of the Spanish stations was on Mulhacen, the most rugged peak of the Sierra Nevada, 11,420 feet high. After incredible difficulties a steam engine with water and fuel and a dynamo were hoisted on top of the peak and an electric light was started on August 20, 1879. Every night was now spent by the Algerian observers in scanning the horizon for the Mulhacen light; it was not, however, until September 10 that they discovered it, a red round star-like disc, 170 miles away.

This is the primary triangulation. The large triangles are now subdivided into smaller ones, so as to establish stations at an average distance of twenty miles. The operations of the secondary triangulation do not require as much precision as those of the primary triangulation and therefore are less expensive. The secondary triangulation is sometimes followed by a tertiary triangulation in which the stations are placed still closer to each other.

The cost of primary triangulations in the United States varies from $598.00 per station in Maryland and Delaware, a rolling country, to $9,031 in California. The stations of the secondary triangulation cost very much less. In the most populated parts of Canada where it is proposed to commence work the cost would probably not be less than $1,000.00 per station.

SESSIONAL PAPER No. 145

*Re* MEMORIAL OF ROYAL SOCIETY.

The contention of the Royal Society that a triangulation is desirable as a basis for other surveys is undoubtedly correct; it would impart to these surveys a degree of accuracy which is lacking at present. The benefit would not be confined to any particular kind of surveys; it would apply to all. Whether Canada has reached that stage of development where such a work can be inaugurated is not quite so clear. Even if restricted to the most populated parts of Canada, the triangulation would cover the Maritime provinces, the whole breadth of Quebec and the Peninsula of Ontario: that is an enormous undertaking. It must be borne in mind that in Europe, in India and in other countries where there are standing armies, triangulations are made by the army engineers whose salaries and maintenance have to be paid whether they are kept idle or employed on survey work. The extra expenditure is limited to the cost of instruments and transportation, which is very small. It is not so in Canada; the salaries and maintenance of all those employed on the work must be provided for. Before coming to a decision, it will, therefore, be wise to thoroughly investigate the subject, and the suggestions of the Royal Society that a Commission be appointed for the purpose seems to be timely.

A trigonometrical survey may not be the only way of improving the surveys of the Dominion. The Land survey, the Geological survey, the Hydrographic survey, the Military survey, &c., have all been developed as separate and independent organizations, each doing its work in its own way and without any regard to the requirements of the other organizations. Could not a Military Survey, for instance, be so made as to fulfil the requirements of the geologist, or is there not some way in which they could help each other? If a Commission were appointed, it might be advisable not to restrict its inquiries to the trigonometrical survey, but to include the whole question of the organization of the surveys under the Dominion Government. After a thorough investigation, it may confidently be expected that the Commission will be able to indicate how the quality of the work of the survey departments and its usefulness to the public can be improved without any material increase in the expenditure.

With a commission consisting of men such as Sir Sandford Fleming, Mr. Thomas Keefer, Professor McLeod, Principal Galbraith or other prominent engineers, the result of the investigation should be worth many times the amount spent upon the Commission.

E. DEVILLE,
*Surveyor-General.*

NOTE.—Cannot procure copies of the plates referred to in the foregoing memorandum.

*The Deputy Minister of the Interior to the Chief Astronomer:*

OTTAWA, April 24, 1906.

Dr. KING,—I am submitting to you a letter which I received some days ago from Mr. Butler, the Deputy Minister of Railways and Canals, with regard to a memorandum which has been submitted to the Prime Minister by the Canadian Society of Civil Engineers, in which it is suggested that some steps should be taken in order to secure a better co-ordination of the several survey departments of the government. I have obtained the views of the Surveyor General on the subject, and I would be glad if you would look into the matter and let me have the benefit of your opinion also.

W. W. CORY,
*Deputy Minister*

*Deputy Minister of Railways and Canals to Deputy Minister of the Interior:*

OTTAWA, April 6, 1906.

W. W. CORY, ESQ.,
Deputy Minister, Interior Department, Ottawa.

DEAR MR. CORY,—You will remember that I spoke to you a short time ago about some steps that should be taken in order to secure a better co-ordination of the several survey departments of the government. In pursuance of this matter, the Canadian Society of Civil Engineers have submitted a memorandum to the Premier.

As the working out of the details necessarily must fall on your department, I beg now to inclose to you a copy of the memorial, and bespeak for it your kind consideration. The matter is one of very great public interest, and every department of the government is, more or less, interested in the subject. Sir Wilfrid will, no doubt, bring it up in Council, and it is certainly desirable that your Minister should be properly informed; and I take this means of reaching him through you, knowing that you will know best how to place the matter before him.

Yours faithfully,
M. J. BUTLER.

## MEMORIAL OF THE CANADIAN SOCIETY OF CIVIL ENGINEERS.

MONTREAL, April 2, 1906.

*Memorandum to the Right Hon. Sir Wilfrid Laurier, Prime Minister of Canada, Ottawa, from the Council of the Canadian Society of Civil Engineers, Montreal.*

As already intimated to you, the following resolution was unanimously adopted at the annual meeting of the Canadian Society of Civil Engineers in Toronto on February 1 last:—

'Resolved that the council be instructed to represent to the Dominion government the importance of action in the direction of a more complete co-ordination of the various surveys conducted by its departments, and the adoption of such methods as will secure permanent records both in the field and in the office of all such work. In the opinion of this meeting, the complete working out of a scheme will involve very careful study not only of the valuable work now being done, but also of the methods which have been adopted by the governments of other countries, and should lead to the establishment of a general topographical and geodetic survey scheme for the whole Dominion.'

In asking your consideration of the foregoing resolution, the Canadian Society of Civil Engineers begs you will understand that the excellence of the survey work which is being done in the various departments of the government is not in any way called in question.

The Society is desirous:—

(a) That some scheme may be arrived at whereby the work of the surveying branches may be co-ordinated in such a manner as will render the work of each of greater and more permanent value to the country than is possible under existing conditions, and it sees no reason why such a result should not be obtained without in any way impairing the independence of the branches.

(b) That a method may be worked out whereby all records once obtained may be accessible, and that all survey monuments, bench and other field marks may be made and referenced in such a manner as to render them permanently available.

(c) That in the development of such a method as may be found best suited to insure the foregoing, the necessity of a general topographical and geodetic survey scheme for the whole of the Dominion be borne in mind as a work which will ultimately be necessary for the complete unifying of the various surveys of the country.

Referring to these requirements, it is understood that there are at the present time in the Dominion Government some eight or more independent or semi-independent surveying branches, each of which conducts its operations after its own methods. These methods being conceived separately and in each case for special objects, do not of course accord, and the results obtained through them cannot be of a uniform standard as regards accuracy or topographical detail. The representations of such work on maps or plans are also carried out under varying methods of projection and on a great variety of scale. Such lack of unity of method and also of proper connection between separate surveys must obviously reduce very largely the permanent value of the work as a whole, and there is therefore not realized from our surveys that return which the money expended upon them would seem to justify.

While during the past years a very large amount of surveying has been done, it is, in regard to some of these surveys, a difficult matter to obtain any desired information for the reason that no adequate method of recording the same has been in vogue, and when the plans or notes of such work are obtained, the field monuments are found not to have been established with that idea of permanence which it is desirable that all survey work should have. It would seem that one of the first objects to be accomplished would be the establishment of a bureau of records, for which a nucleus may now be said to exist in the Department of the Geographer of the Dominion.

The Canadian Society of Civil Engineers is well aware that the Dominion Government has been memorialized by the Royal Society of Canada and by other bodies in regard to the establishment of a geodetic survey for Canada. The Society would gladly see such a work undertaken so soon as the conditions therefor are favourable. It is of opinion, however, that there is a very large amount of work which should first be done in co-ordinating the different surveying branches of the Dominion Government, and that under existing conditions, it would not seem wise to plunge immediately into the large expenditure which would be necessitated by such a general survey. Without question, a geodetic survey for Canada will have to be inaugurated in the near future, but such a survey is one which should grow out of, rather than be superimposed upon, existing conditions. It is furthermore a work which must be approached slowly, not only on account of the circumstances above named, but also for the reason that men must be trained for it.

The Society would respectfully urge the government to appoint a small commission of experts of whom, at least a majority should not be connected with the existing surveying departments, and that this commission be authorized and instructed to obtain such information both in Canada and abroad as will enable it to report upon a satisfactory scheme for the co-ordination of the various surveys now being conducted by the Dominion government, and the adoption of such methods as will secure permanent records both in the field and in the office; these recommendations to be such as will adapt themselves to the establishment of a trigonometrical survey of the country. Further, that the commission be instructed to outline the best methods of inaugurating a geodetic survey for Canada in accordance with the foregoing considerations.

H. D. LUMSDEN,
*President,*

C. H. McLEOD,
*Secretary.*

*Chief Astronomer to Deputy Minister of the Interior:*

May 18, 1906.

W. W. CORY, Esq.,
Deputy Minister of the Interior,

The Canadian Society of Civil Engineers recommend the appointment of a commission of experts to obtain such information, both in Canada and abroad, as will enable them to report upon a satisfactory scheme for:

1. The co-ordination of the various survey departments under the Dominion government.

2. The adoption of such methods as will secure permanent records both in the field and in the office.

3. The making of a general geodetic and topographic survey of the Dominion, at some time in the future, after the co-ordination has been effected.

Their idea that the geodetic survey is a matter of the future is strongly put; they express their dissent from the memorial (December, 1903) of the Committee of the Royal Society, who urged the immediate and pressing need of geodetic surveys in Canada:

The Engineers say:

'The Canadian Society of Civil Engineers is well aware that the Dominion government has been memoralized by the Royal Society of Canada and by other bodies in regard to the establishment of a geodetic survey for Canada. The society would gladly see such a work undertaken as soon as the conditions therefor are favourable. It is of opinion, however, that there is a very large amount of work which should first be done in co-ordinating the different surveying branches of the Dominion government and that, under existing conditions, it would not be wise to plunge immediately into the large expenditure which would be necessitated by such a general survey.'

Now co-ordination in its mathematical sense means the reference by means of 'co-ordinates' to a basal system. Thus different surveys are co-ordinated with one another by so connecting them by accurate measurements that on the resulting maps there will be no overlap of different surveys or gap between them.

This species of co-ordination, however, is the work of a geodetic survey, and this the engineers do not want at present.

Hence we must conclude that 'co-ordination' in the paragraph quoted has the general meaning of 'harmonizing' the different surveys, putting them on the same basis.

This might denote unification of management, adoption of like methods, establishment of like standards of accuracy, or the organization of each individual survey, whether it be a land, or a topographical survey, or a survey of engineering construction, in such a way as to collect at once all the data which are the object of all the different classes of survey. The first of these is barred by the admission that it is not proposed to interfere with the independence of the different survey departments.

To estimate the value of the suggestion in regard to the other points, let us consider the different surveys now being made by the Dominion government. The principal ones are:

1. Surveys of Dominion lands.
2. Surveys of International Boundaries.
3. Hydrographic Surveys (Marine Dept).
4. Topographical Surveys by the Geological Survey.
5. Topographical Surveys by the Militia Department

6. Transcontinental Railway Survey, Georgian Bay Canal Survey, and generally surveys for engineering construction, made by or under the Railways and Canals and Public Works Departments.

It will be seen that the allegation often made that different survey departments in Canada are covering the same ground is hardly correct. The Dominion Lands Surveys are confined to the west, International Boundary Surveys lie along the actual boundary line, and only touch the edge of Dominion Lands and in the prairie region only. Hydrographic surveys are necessarily confined to the water. The Geological Survey and the Militia Department are indeed carrying on surveys alike in their general object, but the latter is principally interested in the country adjacent to the boundary line, while the Geological Survey Department requires topographical surveys in order to trace out the rock formations wherever its work lies, that is, over the whole of Canada.

The engineering surveys under No. 6 need hardly be considered in relation to those under the other heads, since they are of special character, seeking a minuteness of local detail which is unnecessary in the more general surveys. While a good topographical survey, if such existed, would aid in preliminary location, it would not supersede the final construction survey. The engineering surveys on the other hand furnish excellent topographical data especially as to levels, over the region they cover and thereby would assist a topographical survey. It is, however, clearly impossible to amalgamate them with a general topographical survey.

The International Boundary Surveys are carried on as a joint undertaking with the United States, under treaty or agreement. The methods, standard of accuracy, &c., of the Canadian and American surveyors have to be, and are, 'co-ordinated.' These methods and standard are not necessarily the best for general use in Canada. It seems necessary therefore to leave these surveys out of any general scheme of co-ordination.

The application of the proposed co-ordination is therefore restricted to Dominion Land Surveys and the topographical surveys of the Geological Survey and Militia Departments.

The object of the Dominion Land Surveys is to lay out lands for settlement, by running and marking the township and section lines, &c. These lines may indeed serve as a basis for topographical surveys, to a degree of accuracy sufficient for present purposes, in the west. But to impose on the land surveyor the additional duty of completing the topographical survey would hamper him in his proper work, and would thereby, with little doubt, involve an expense greater than making the survey of topographical detail over the same ground independently. Likewise, it is impossible for the surveyor making a topographical survey to profitably apply it to the laying down of township and section boundaries.

Hence, after all, the question is reduced to the co-ordination of two survey departments, the Geological Survey and the Militia. It would no doubt be very advantageous to both these departments to have a common standard of accuracy and a common scheme of work whereby they could assist each other

But they find difficulty in reaching any defined standard of accuracy, from the want of well determined points to serve as control.

This want can only be effectively satisfied, as the Royal Society in their Memorial, Major General Lake in his memorandum to the Minister, and others have pointed out, by a scheme of triangulation.

If the control points are provided, there will then be no difficulty in making topographical surveys to any required degree of accuracy.

In this view 'co-ordination' is an effect which will follow naturally upon the institution of a triangulation, and the appointment of a 'committee of experts' to attempt to do anything before this is an absurdity. It is rather strange moreover to find a recommendation made to the effect that of this committee 'at least a majority should not be connected with the existing survey departments.'

This sentence seems to intimate more than it says and to suggest a desire to exclude altogether those who have practical knowledge of the conditions which would have to be met in framing an improvement on survey methods. Also, to send this commission 'abroad' to study a Canadian question would seem unnecessary.

It is to be observed that the views set forth in the present memorandum are not at variance with Major Gen. Lake's suggestion of an inter-departmental conference. He recommends that the triangulation, to provide the control points, be made by the Department of the Interior, and that a conference between the different survey branches should be had with a view to co-operation in the execution of the topographical survey based on this triangulation. His proposal is practical and definite.

There remains for consideration the second point of the recommendation of the Engineers, 'the adoption of such methods as will secure permanent records both in the field and in the office of all such work,' so that 'records once obtained may be accessible and that all survey monuments, bench or other field marks may be made and referenced in such a manner as to render them permanently available.'

There is no doubt that the proper placing of permanent marks of the surveys is desirable, and their proper referencing is also most important.

As far as surveys made under the Department of the Interior are concerned, they have all been marked in as permanent a way as possible under the circumstances, taking due consideration of cost. The referencing of the returns of survey is also very complete. The plan and field notes of any township or section line surveyed from the beginning of these surveys, 35 years ago, are immediately available whenever asked for.

The case is probably the same in the other departments, and the only difficulty which the public may find in getting the information wanted, will therefore be in knowing which branch to apply to, where similar work is carried on by different departments. The suggestion therefore of the Engineers that records (or copies of them) be filed in one office, such as that of the Geographer of the Interior, is worthy of consideration. An inter-departmental conference (not an outside commission) would be the proper body to deal with this question. The systematic keeping of records would also be assisted by the systematizing of the field work, through a geodetic survey.

A good deal has been said as to the possible cost of a geodetic survey, and the consequent inadvisibility of the Government undertaking it, until the matter has been considered in all its bearings.

The cost of a survey of Canada has been estimated at ten to twenty-three millions, and it has been suggested that this is a minimum, and that the cost will probably be much greater. The Government is therefore cautioned against the hasty incurring of such a liability.

This is hardly the proper way to look at the question. The geodetic survey is not like a railway, which once begun, must necessarily be completed from end to end, under penalty of wasting the capital already invested. A geodetic survey on the other hand may be made to cover as much or as little ground as may be desired, from a few hundred square miles up. If at any time it is found to be costing more than it is worth, it may be discontinued without loss of the benefits accuring to the area already surveyed.

It would appear to be good business policy for the Government to carry on the geodetic survey on a small scale, using as far as possible the present departmental organization. If it turns out to be too expensive, then is the time to call in the 'committee of experts' to decide whether methods can be improved in the interest of economy, or whether the survey should be altogether discontinued.

As to the figures of cost, Major Hills in his report on the Survey of Canada estimates the cost according to his scheme at $75,000 per annum. This capitalized at 3 per cent amounts to $2,500,000 which is therefore the maximum total cost. It is true

that he suggests that this cost may be increased after the first few years, but there is a wide margin between two and a half millions and the other sums which have been mentioned, and it may be assumed that if after the first few years, it were decided to increase the expenditure, it would be because the survey is found to be of such value as to warrant covering a more extended territory.

The immense sums which have been put forward as estimates of cost have probably been derived by multiplying the total area of Canada in square miles (3,600,000) by some assumed cost per square mile, such as $10 in Major Hills' estimate.

This area includes all the northern uninhabited regions, including the Arctic islands. The extension of the topographical survey over these, or over any except the best settled parts of Canada is not a present-day problem.

Let the question of cost be looked at in the light of the reasonable scheme set forth in this memorandum, and which the undersigned was tentatively authorized by the Minister to go on with last summer, namely, the gradual extension of the triangulation where most needed. The cost at ten dollars per square mile is less than two cents per acre, which should not be considered too heavy a burden for the valuable lands of southern and eastern Canada.

Respectfully submitted,

W. F. KING,
*Chief Astronomer.*

*Report of the 'Committee on Surveys' to the Minister of Militia and Defence.*

OTTAWA, February 15, 1907.

To the Honourable
The Minister of Militia and Defence.

SIR,—We, the undersigned members of the Committee on Surveys, constituted pursuant to the Order in Council dated November 13, last, have the honour to report as follows :—

A meeting, for the purpose of organization of the representatives of the Departments named in the Order was held on the 20th December. Meetings of the full committee have been held on the 7th and 17th January and each week since. To the Committee provided for in the Order, a representative of Laval University has been added.

As the result of our discussions we beg to submit the following conclusions.

1. The Committee is of opinion that a comprehensive and reliable survey of the Dominion for the production of an accurate topographic map, based upon a network of triangulation and showing the natural and artificial features of the country, is of urgent necessity to the people of Canada, from the standpoint of public economy, the extension of public undertakings and the development of the natural resources of the country.

Public economy will be served by the early production of accurate maps, by the collection and record of reliable data for the benefit of all parties interested, public or private, and by the avoidance of the duplication or overlapping of survey work which at present frequently occurs, different parties surveying the same area independently for different purposes.

The extension of every class of public undertaking will be promoted, because such topographic maps will greatly assist in the location of roads, railways, canals, water supply, drainage and irrigation works. This has been found to be the case in all countries where such maps have been produced.

Development of the natural resources of the country will be furthered by the assistance which a reliable survey will afford to the geological examination of areas likely to possess mineral deposits, by the information it will give as to the location of agricultural or timber lands, and by the data it will afford for the preliminary investigations of water-powers, waterways, or other natural aids to industrial enterprise.

A reliable topographic map of Canada is absolutely essential for military purposes, to afford the fullest possible information as to the configuration of the country, its natural and artificial features.

It would be a basis for maps graphically illustrating all matters in connection with statistics such as population, industries, the products of the country, the areas of economic minerals and forests, qualities of soil, drainage and catchment basins of rivers and streams, the position of water-powers and the like.

An important benefit to be derived from a topographic and hydrographic survey would be the accurate delineation of the coast line of the Atlantic and Pacific seaboards and the inland waters. It is inevitable that until this is accomplished many disasters must happen to shipping, which might be avoided in a great measure, if there were reliable charts of these waters. One of the first requisites in making hydrographic surveys for the production of accurate charts, is that control points must be accurately established on the shore. Large sums of money are annually expended on harbours, lighthouses and other improvements, yet in many cases the geographical positions of these harbours and improvements have not been accurately determined.

In political and legislative matters, a topographic map would furnish useful and accurate information as to the boundaries of villages, towns, municipalities, &c., and it would also be of great utility in the administration of all public works and services.

It is possible with a good topographic map to plan and lay out engineering works to better advantage than by means of the ordinary preliminary survey. A topographic map would thereby effect not only a saving of large sums of money now annually expended by the government and by private companies in surveys for such undertakings, but would minimize to a great extent the cost of construction, since a better location may be obtained in many cases from a topographic map than from preliminary surveys.

In short, the benefits arising from a good, general topographic survey may well be described as practical, political, administrative, military, statistical and economic.

2. The elaboration of a comprehensive scheme that will permit of a satisfactory co-ordination of existing survey material, whether due to the work of government survey departments or to private enterprise, is also a matter of national importance and great practical utility to the people of Canada.

For the proper co-ordination of existing surveys and the effectual control of future surveys, it is necessary to establish in a permanent manner the net work of triangulation, already referred to, so as to provide a series of points of reference, at convenient distances apart, whose geographical position and absolute altitudes have been accurately determined by appropriate astronomical observations, chains of refined geodetic triangulations and nets of precise spirit levelling.

3. Provision should be made for perpetuating bench marks, points of control, and important points in the interior detail of surveys by permanent monuments. This rule should be applied to all surveys of standard accuracy made under Dominion authority.

4. In order to secure the maintenance of adequate records, there should be a central record office in a suitable fireproof building, where the results of all surveys, inclusive of accurate copies of plans and profiles with brief descriptions should be filed. For purposes of reference, these documents when not required to be treated as

confidential should be made readily accessible to all departments or branches of the government service and to the public.

Deposit in this office of all such results, plans or other documents should be made compulsory upon the departments conducting surveys, and upon railway and other companies working under Dominion charter.

5. It is highly desirable that all general and sheet maps should be produced under standard arrangement as regards scale, projection and execution.

For the production of such maps the existence of a central bureau, where maps may be compiled, edited and engraved for the general survey and, on repayment, for other departments requiring the same would present many advantages. This provision should not prevent any department equipped for the purpose, from preparing its own plans or maps.

6. In order to secure unity, co-ordination, and efficient administration, as well as the systematic utilization of all survey material, and for the production in sheets of an accurate topographic map of Canada, it is desirable that the controlling and topographic surveys, the land triangulation basis of the Hydrographic Survey and the Map Bureau and Record Office should form branches of one department of the public service.

It is also desirable that these branches should be included with the Department of the Geological Survey, together with such other branches of the public service as deal with the natural resources of the Dominion and the quality of whose work depends largely upon accurate maps of the areas under investigation.

7. The prosecution of surveys for special purposes, such as construction of canals or railways, improvements of rivers and harbours, laying off land for settlement, and the like, would be left to the departments to which these matters now appertain, but the departments interested in such surveys should be invited to carry them out, so far as consistent with the end in view, in accordance with such system as may appear best adapted to render the results of permanent value for topographic purposes.

8. The co-operation of the provincial survey departments should be invited.

9. It is not contemplated that surveys extending over the whole country should be undertaken at once. Their extent must be determined by the urgency of the requirements, and the control survey would in the first instance be confined to the better settled parts of the country and to those portions where geological and other researches into the natural resources of the country demand reliable maps upon which to base their operations.

The appropriations in the estimates now before parliament give for the work of the branches which we recommend should be brought together.

| | Salaries and expenses. |
|---|---|
| Geological Survey, Superintendent of Mines Branch | $242,475 |
| Astronomer's Branch, Boundary Surveys | 269,067 |
| Hydrographer's Branch, including new steamer. Tidal Survey | 349,500 |
| Geographer's Branch | 58,890 |
| Total | $919,932 |

The money provided in these estimates if administered under unified management, is sufficient, subject only to such natural development as may take place in the future, for the establishment of a systematic survey, without additional appropriation therefor by Parliament.

Of the sums mentioned above there is available for field work of surveys:—

| | |
|---|---|
| Geological Survey | $ 25,000 |
| Astronomical Branch, including Boundary Surveys and Trigonometrical Survey | 204,000 |
| Hydrographic Branch | 150,000 |
| | $379,000 |

Out of the Chief Astronomer's vote, $50,000 has already been noted in the estimates as for the trigonometrical survey, in connection with which some work has been done in the vicinity of Ottawa in 1905 and 1906, and triangulation forms part of the plan of operations of the International Boundary Surveys. A portion of the expenditure for the latter, say $10,000, may consequently be credited to control work, making with the $50,000 above mentioned, a total of $60,000 available for purposes of control.

This will be sufficient to carry on the triangulation eastward from Ottawa towards Montreal and the Richelieu river, to conduct some triangulation on the River St. Lawrence to assist the hydrographer who will thereby be enabled to devote the funds at his disposal more directly to sounding, &c., and to contribute towards the control work in the west, such as the continuation eastward along the 49th parallel of the boundary survey triangulation. All this work is such as will necessarily be included in the geodetic survey as soon as the methods of conducting the latter and the areas over which it shall extend shall have been determined.

Meanwhile the control work may be gradually extended over the country, connecting the new surveys and correcting the old. It is thought that, with the union of the surveying departments mentioned, it will be possible in future years so to distribute the funds devoted to surveys among the several branches as to develop the topographic map systematically.

The inauguration of a systematic survey of Canada, therefore, calls for no immediate increase of expenditure. Whether there shall be increase, or continuance of the present expenditure in the future is a matter for future decision, based on consideration of the cost of the work in relation to the beneficial results obtained from it. This decision will rest wholly with the government and parliament.

10. For the complete working out of all the details which will arise from the foregoing, and especially to provide for that accord which is necessary in the operations of the several survey branches of the Dominion, a permanent Survey Board should be appointed.

The board should be similar in composition to the present Survey Committee, and have power to call in consultation such other persons as from time to time it may desire.

The board should advise as to the development and methods of the control survey. It should suggest such regulations as it might consider necessary or desirable regarding all surveys and mapping and should invite co-operation towards securing the practical application of the same. It should constitute a board of conference for the several survey departments.

A reasonable appropriation, say $8,000 per annum, should be made for the necessary expenses of the board.

In the event of these recommendations receiving the approval of the government the immediate appointment of the board is urged, in order that they may undertake their duties without delay.

We append hereto:—

1. A number of extracts from statements or reports from various authorities showing the practical benefits derived from topographic surveys.

2. A copy of the Order in Council of November 13, 1906, under which we have acted.

3. A copy of the memorial from the Council of the Canadian Society of Civil Engineers.

W. F. KING, *Chairman,*
*Chief Astronomer, Department of the Interior.*

M. J. BUTLER,
*Deputy Minister and Chief Engineer, Department of Railways and Canals.*

P. LAKE,
*Chief of the General Staff, Department of Militia and Defence.*

*E. DEVILLE,
*Surveyor General, Department of the Interior.*

*R. STECKEL,
*Chief Clerk, Engineering Branch, Department of Public Works.*

W. J. STEWART,
*Chief Hydrographic Surveyor, Department of Marine and Fisheries.*

C. H. MCLEOD,
*Professor of Surveying and Geodesy, University of Montreal.*

L. B. STEWART,
*Professor of Surveying and Geodesy, University of Toronto.*

E. MARCEAU,
*Principal of Polytechnic School, Laval University.*

Attest:
J. MACARA,
*Secretary.*

## APPENDIX I. TO REPORT OF COMMITTEE ON SURVEYS.

*Extracts from statements or reports from various authorities showing the practical benefits derived from Topographic Surveys.*

President Van Hise, of the University of Wisconsin, says:—"A railroad company owned two lines in northern Michigan and Wisconsin which they wished to connect by a branch some forty miles in length. The country was unknown between the two lines. Under my direction, topographical, geological, and timber maps were made of about twelve hundred square miles, at a cost of about $25,000. After these maps were made the line was laid down in the office with a beautiful grade, and with the best location possible with reference to iron ore and timber. One of the features of the line was that it crossed a bold trap range which was supposed to be impossible to cross except at great expense, by finding gaps through it. This line crossed the branch of another railroad about twelve miles long, which, because it went around the end of this trap range, when the gap was directly in front of it, was at least two miles longer than was necessary. These additional two miles of road cost fully as much as the entire survey of the twelve hundred square miles.

It is my profound conviction if topographical surveys were made of broad zones where it is expected to project railroads through rough forested country, that many times the cost of the survey would be saved in the construction of the railroads, besides getting a better location both as to resources and to grade than is possible by the random methods employed at the present time for the locating of railroads in rough forested country."

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*This report was signed by Messrs. Deville and Steckel, subject to the objections set forth in their appended minority reports.

The statement has been made by General Francis A. Walker that "if the State of Massachusetts and had a good topographical map in 1836 some $20,000,000 would probably have been saved in its public railway expenditure."

The area of the state of Massachusetts being 8,315 square miles, this saving would amount to over $2,400 per square mile. The topographic survey of the State has cost $13.00 per square mile.

In the report of the geographer to the Department of the Interior for 1902, Mr. White, alluding to the difficulties met with in compiling the map of Canada on a scale of thirty-five miles to an inch wrote:—"The lack of an accurate topographical survey, the numerous sources from which information must be obtained, the difficulty in many cases of obtaining access to the plans of old and almost forgotten surveys, the necessity of incorporating surveys that are being made concurrently with the compilation of the map, which frequently alter the work almost as soon as completed, all tend to make the compilation of such a map a long and tedious operation."

Further on in the same report he wrote:—

"The difficulties encountered in compiling the new map of Canada emphasize the need of a good topographical survey of at least the well settled portions of the Dominion.

A few years ago I made a survey between two well determined points on Georgian Bay and the west end of Lake Ontario respectively, which showed that part of Central Ontario as shown in the best existing map was over two miles out in longitude, and over a mile in error in latitude. Although our maps show streams, lakes, &c. even in the extreme north, much of the information upon which they are based is of the vaguest kind."

Major C. P. Close, C.M.G., R.E., Instructor in Surveying at the School of Military Engineering, Chatham, in a lecture delivered at the staff college on 13th July, 1903, said:—"No assemblage of sketches will ever make a topographical map. The maps of India, previous to 1802 (when the survey department began work) had been compiled from sketches. These maps, in the short distance across India in the latitude of Mysore, were forty miles in error, a striking example of the futility of basing maps on sketches."

Again, speaking of the recent experience in South Africa he said:—"Instances have been quoted of the impossibility of compiling a satisfactory map from sketches. South Africa affords the example of the impossibility of compiling a map from large scale plans, such as the farm surveys of the Free State."

Dr. Frank D. Adams in a recent paper read before the Canadian Institute, quotes from a letter from Dr. C. D. Walcott, lately director of the United States Geological Survey as follows:—"Such maps" (those of the U.S. Geological Survey) "are an essential to the proper development of all the resources of a state. We have reached the point where officials of railroads, of trolley lines, those interested in highway improvements and in the development of city water supplies and sanitary measures as in general engineering work, do not think of spending one dollar on field surveys until they have first procurred from this office the topographic maps and the records of levels run in connection therewith. We are in daily receipt of testimonials showing the sums of money and the time saved in connection with all preliminary and also of some location surveys for such enterprises. Above all, however, is the topographic map, an essential to the study, along modern lines and by best methods, of the mineral resources of a region. The old descriptive methods of discussing the geology of a district have been long abandoned in this country. It has been found that every dollar expended in preparing a mathematically correct base map upon which to map the geologic formations for strike and dip and from which to construct structural sections, is returned many fold in the value and accuracy of the resulting studies of the geologic formations and their economic possibilities. A good topographic map is just as essential a framework upon which to reproduce a facsimile of the underlying geology,

as is the steel frame which modern architects use to form and support a masonry building of modern design."

In 1898, Dr. Pritchett, Superintendent of the U.S. Coast & Geodetic Survey, presented before the Royal Society of Canada a paper on "A plan for international measurement of an arc of the 98th meridian," in which the co-operation of Canada was invited.

The Royal Society in memorializing the Governor-General in Council in support of Dr. Pritchett's proposal, while speaking of the importance of the work from a scientific standpoint, urged co-operation by the Canadian government, on the ground that 'the Canadian portion of it would also be of great practical utility in forming the basis of a thorough geographical survey for this Dominion.'

They further say:

'Extensive triangulations have seldom been undertaken upon scientific methods alone, their primary object has been utilitarian and to provide a basis for systematic surveys. Without such a basis there is no finality in results, the same ground is being surveyed over and over again, as is the case in the Dominion, by the land surveyor, the geologist, the railway and canal engineer, the hydrographer. For every new project a new survey has to be made. The labour and expenditure on these surveys would be considerably reduced and often entirely unnecessary if we had a systematic triangulation carried out as in other countries. This fact has long been recognized in Europe, where every country has been accurately mapped. Outside of Europe may be cited the United States whose triangulation is well advanced; India, which offers a striking instance of extensive and well conducted surveys; the Cape of Good Hope and Natal, which have executed a joint triangulation of South Africa; New Zealand, where trangulation has preceded all other surveys. It must not be supposed that there were no objections raised in these countries to the inception of the work; on the contrary, it was frequently opposed by those who did not understand its practical value, but their opinions changed after they had been in a position to appreciate its usefulness.'

The desirability of a trigonometrical survey of the Dominion was brought before the government in 1888 by a committee, appointed for that purpose, of the Dominion Land Surveyors' association. The following is an extract from the memorandum:

'Again with the increase in the value of real property any work having in view the permanent marking of points which would definitely fix the positions of boundaries of real estate, is for the public good. In many of the provinces the boundaries of valuable properties are in most cases dependent on the durability of wooden posts, a few marks on trees, for the testimony of a few of the oldest inhabitants, and as a consequence expensive litigation often arises, in fact it may safely be said that the amount annually expended in litigation regarding boundaries would go a long way towards paying for the cost of a trigonometrical survey.

Were the boundaries, especially those of large areas, such as counties, townships, and concessions, accurately defined by a trigonometrical survey similar to that made by the countries herein referred to, all doubts as to their position would be forever set at rest.

At the present time, throughout the Dominion, every city and many of the towns and villages are looking about for means of obtaining a good water supply or of improving the supply they have.

Gravity being the best method of utilizing a water supply, is generally sought after, but the information necessary to determine the availability of a supply by this means, can now only be had by expenditure of large sums in surveys, as has been lately seen in Toronto.

Had there been a good topographical map in existence, that expenditure would have been unnecessary.

In drainage work the information derivable from a survey of this kind would be invaluable, and as our agricultural population is waking up to the benefits arising from proper drainage, no time should be lost in giving them this aid. The maps would enable any engineer to determine by calculation the area of any basin to be drained, and to know accurately the size of drain necessary, and its proper location, and the survey would do away with all litigation arising from parties claiming that their lands do not lie in the basin to be drained, as a reference to the map would show at a glance the natural drainage outlet for any piece of land.

These maps would also be exceedingly valuable in assisting an equitable assessment of real estate for taxes, and providing the necessary information required in locating and building highways, and would save large sums of money which are now expended in finding out where roads should be built, and the sums saved might be expended in making the roads more solid and permanent.

The information afforded by the maps provided from a survey of this kind, in reference to our inland waters, and the possibility of their utilization for navigation which is becoming every day of more importance would be a vast benefit to the country.

Many large public works are now being agitated, and will no doubt in the near future be undertaken, as, for instance, 'The Ottawa Ship Canal,' 'The Trent Valley Canal,' &c., the possession of good topographical maps would very materially assist in settling the question of the feasibility of these and many other schemes for the improvement of navigation, &c.'

## Appendix II. to Report of Committee on Surveys.

### order in council constituting the committee.

*Extract from a Report of the Committee of the Privy Council, Approved by the Governor-General on the 13th November, 1906.*

On a report dated 19th July, 1906, from the Minister of Militia and Defence stating that he has had under consideration a memorandum from the Council of the Canadian Society of Civil Engineers, Montreal, dated 2nd April, 1906, containing a resolution adopted at the annual meeting of the said society on the first of February, 1906, which advocates a more complete co-ordination of the surveys conducted by the various departments of the Dominion government with a view to the eventual establishment of a general topographical and geodetic survey scheme for the whole Dominion.

The Minister observes that the immense importance from a military point of view of a correct topographical survey of the Dominion has already been reported on by the Chief of the General Staff and the said report has been approved of by the Minister of Militia and Defence.

The Minister further states that he is in agreement with the general proposal contained in the memorandum of the council of the Canadian Society of Civil Engineers, and is strongly in favour of the co-ordination of the work of the existing survey branches of different government departments with a view to the inauguration of a geodetic survey of Canada.

The Minister further states that upon one point only is the policy of the Department of Militia and Defence not in complete accord with the council of the society. In the last paragraph but one of their memorandum the council deprecate entering at once on the expenditure that would be necessitated by the establishment of a geodetic survey although they admit that one will have to be inaugurated in the near future. They argue that such a survey should 'grow out of' rather than be 'superimposed upon' existing conditions. It may be that the meaning which council of the society attach

to the expression 'Geodetic Survey' has been misinterpreted, but in the view of the Minister of Militia and Defence, the most valuable portion of a 'Geodetic Survey' from a practical point of view is that it furnishes in its triangulation, the accurate frame work upon which all other surveys must be based, if they are to be reliable. If this frame work is, in the words of the council, to 'grow out of existing conditions', there would surely be a risk not only of delay, but a wasted effort.

The Minister further states, that the Council of the Society admit that different Government survey branches are working under different conditions, upon different methods, under varying projections, and without connection. It is difficult to understand how results are to be co-ordinated without the general frame work furnished by a geodetic survey. And, it would further appear that, inasmuch as the different branches are necessarily basing their work upon imperfect data, to delay the commencement of the frame work of triangulation upon which the accurate survey of the country must ultimately be based, is to condemn these departments for a greater or less period to work under conditions which forbid accuracy, and to waste a great portion of skilled work of the surveyors employed therein.

The Minister, while cordially supporting, subject to the foregoing reservation, the general proposals made in the last paragraph of the Memorandum of the Canadian Society of Civil Engineers, is not entirely prepared to agree with the Council of the Society that a majority of the commission of experts proposed by them should be persons not connected with the existing Survey Departments.

The Minister of Militia and Defence is of opinion that it is more desirable that the committee which would perhaps be preferable to a commission as being less expensive should be composed mainly of officials representing the different Government Departments concerned with survey work.

The Minister, therefore, suggests that the Department of the Interior, as the one perhaps most deeply interested in the question should supply two members to the Committee, one of whom possibly the Dominion Astronomer, might sit as Chairman, that the Geological Survey, the Department of Marine and Fisheries, the Department of Railways and Canals, the Department of Public Works and the Department of Militia and Defence should each nominate one member to represent its interests. It is for consideration whether the Committee would not be strengthened by the addition of representatives from the scientific staff of McGill and Toronto Universities, say one member from each. The Committee concurring in the foregoing recommends that the same be approved.

JOHN J. MCGEE,
*Clerk of the Privy Council.*

## APPENDIX III. TO REPORT OF THE COMMITTEE ON SURVEYS.

MONTREAL, April 2, 1906.

*Memorandum to the Right Hon. Sir Wilfrid Laurier, Prime Minister of Canada, Ottawa. From the Council of the Canadian Society of Civil Engineers, Montreal.*

As already intimated to you, the following resolution was unanimously adopted at the Annual Meeting of the Canadian Society of Civil Engineers, in Toronto on 1st February last:—

'Resolved that the Council be instructed to represent to the Dominion Government the importance of action in the direction of a more complete co-ordination of the various surveys conducted by its departments, and the adoption of such methods as will secure permanent records both in the field and in the office of all such work. In the opinion of this meeting, the complete working out of a scheme will involve very

careful study not only of the valuable work now being done, but also of the methods which have been adopted by the Governments of other countries, and should lead to the establishment of a general topographical and geodetic survey scheme for the whole Dominion.'

In asking your consideration of the foregoing resolution, the Canadian Society of Civil Engineers begs you will understand that the excellence of the survey work which is being done in the various departments of the government is not in any way called in question.

The Society is desirous:—

(*a.*) That some scheme may be arrived at whereby the work of the surveying branches may be co-ordinated in such a manner as will render the work of each of greater and more permanent value to the country than is possible under existing conditions, and it sees no reason why such a result should not be attained without in any way impairing the independence of the branches.

(*b.*) That a method may be worked out whereby all records once obtained may be accessible, and that all survey monuments, bench and other field marks may be made and referenced in such a manner as to render them permanently available.

(*c.*) That in the development of such a method as may be found best suited to insure the foregoing, the necessity of a general topographical and geodetic survey scheme for the whole of the Dominion be borne in mind as a work which will ultimately be necessary for the complete unifying of the various surveys of the country.

Referring to these requirements, it is understood that there are at the present time in the Dominion Government some eight or more independent or semi-independent surveying branches, each of which conducts its operations after its own methods. These methods being conceived separately and in each case for special objects, do not of course accord, and the results obtained through them cannot be of a uniform standard as regards accuracy or topographical detail. The representations of such work on maps or plans are also carried out under varying methods of projection and on a great variety of scale. Such lack of unity of method and also of proper connection between separate surveys must obviously reduce very largely the permanent value of the work as a whole, and there is therefore not realized from our surveys that return which the money expended upon them would seem to justify.

While during the past years a very large amount of surveying has been done, it is, in regard to some of these surveys, a difficult matter to obtain any desired information for the reason that no adequate method of recording the same has been in vogue, and when the plans or notes of such work are obtained, the field monuments are found not to have been established with that idea of permanence which it is desirable that all survey work should have. It would seem that one of the first objects to be accomplished would be the establishment of a bureau of records, for which a nucleus may now be said to exist in the Department of the Geographer of the Dominion.

The Canadian Society of Civil Engineers is well aware that the Dominion Government has been memorialized by the Royal Society of Canada and by other bodies in regard to the establishment of a geodetic survey for Canada. The society would gladly see such a work undertaken as soon as the conditions therefor are favourable. It is of opinion, however, that there is a very large amount of work which should first be done in co-ordinating the different surveying branches of the Dominion Government and that under existing conditions, it would not seem wise to plunge immediately into the large expenditure which would be necessitated by such a general survey. Without question a geodetic survey for Canada will have to be inaugurated in the near future, but such a survey is one which should grow out of, rather than be superimposed upon, existing conditions. It is furthermore a work which must be approached slowly, not only on account of the circumstances above named, but also for the reason that men must be trained for it.

The Society would respectfully urge the Government to appoint a small commission of experts of whom at least a majority should not be connected with the existing surveying departments, and that this commission be authorized and instructed to obtain such information both in Canada and abroad as will enable it to report upon a satisfactory scheme for the co-ordination of the various surveys now being conducted by the Dominion Government and the adoption of such methods as will secure permanent records both in the field and in the office; these recommendations to be such as will adapt themselves to the establishment of a trigonometrical survey of the country. Further, that the Commission be instructed to outline the best methods of inaugurating a geodetic survey for Canada in accordance with the foregoing considerations.

H. D. LUMSDEN, *President.*
C. H. MCLEOD, *Secretary.*

## COMMITTEE ON SURVEYS.

### MINORITY REPORT BY THE SURVEYOR GENERAL.

*Memorandum of the objections of the Surveyor-General to the report of the majority of the Committee on Surveys.*

Clause 1. In describing the benefits to be secured by a comprehensive survey of the Dominion, savings and economies are mentioned. This should be qualified by explaining that it does not mean a saving in the total cost of surveys as a whole.

The statement that many disasters must happen to shipping which might be avoided in a great measure if there were reliable charts of the inland and coast waters, might be understood to mean that no reliable charts are in existence and that none can be produced without a geodetic and topographic survey. No evidence has been submitted to the Committee in support of this contention.

Clause 2. According to the recommendations of the Society of Civil Engineers approved by the Order in Council of November 13, 1906, the Committee, which takes the place of the Commission suggested by the Society, was to be authorized and instructed to obtain such information, both in Canada and abroad, as would enable it to report upon a satisfactory scheme for the co-ordination of the various surveys now being conducted by the Dominion Government.....Further,..... .....to outline the best methods of inaugurating a geodetic survey of Canada.

The information referred to has not been obtained, nor has a scheme been devised for the co-ordination of the various surveys or a method been outlined of inaugurating a geodetic survey of Canada. Clause 2 merely suggests the elaboration and adoption of a comprehensive scheme, but does not define what it is to consist of or how it is to be carried out.

Although the benefits to be derived from good maps are fully appreciated, financial considerations have hitherto prevented the inauguration of a comprehensive survey of the country. The cost of a survey is in direct proportion to the area, while the revenue, from which payment must be made, varies with the population. The conditions in Canada are unique; with an area of four millions of square miles, larger than the whole of Europe, the revenue (1905) is only $71,180,626, or $17.80 per square mile. Taking Great Britain, for instance, for the purpose of comparison, it is found that the area is 121,000 square miles and the revenue £143,370,404, or $5,770 per square mile. Great Britain is thus in a position to spend 324 times as much as Canada for surveying a square mile. In other words, where Great Britain spends $32.40 for surveying a square mile, a proportionate expenditure for Canada is ten cents. This

shows that Canada cannot follow blindly the lead of other countries in this matter; because a certain kind of survey has been found a profitable investment elsewhere, it does not follow that it will also prove profitable here.

Another consideration is that in Europe surveys are generally made by military officers and soldiers, for whom employment has to be found in time of peace. Their salaries and maintenance having to be paid whether they are idle or employed, the extra expenditure is limited to the cost of instruments. transportation and contingencies, which is small. In the published figures of the cost of such surveys, salaries are not always included and in consequence the cost may come out very low.

If estimates for a survey of Canada are calculated from figures of this kind, disappointment is inevitable as salaries form two-thirds of the cost of Canadian surveys.

It must also be borne in mind that nearly all countries which have been surveyed are well settled and sparsely wooded, that the communications are easy and transportation inexpensive. Opposite conditions govern in Canada; the primeval forest is still within a few miles of many of our great cities and the surveys are in consequence more expensive than elsewhere.

A project for a survey of part of Canada has been submitted by Major Hills. C.M.G. He estimates the cost at ten millions of dollars for a map on a scale of two miles to an inch, and twenty-three millions for a scale of one mile to an inch. Whether the survey can be executed for the sums mentioned and whether it is the kind of survey best adapted to the needs of Canada are questions requiring investigation. While valuable for military purposes, the two miles to an inch survey could not well be used for the location of roads, railways, canals, works for water supply, drainage, irrigation and the like.

From the foregoing it may be perceived that a geodetic and topographical survey of Canada is an enormous undertaking and that it would not be wise, without mature deliberation, to commit the country to the large expenditure involved.

Clause 5. A central bureau where maps may be compiled, edited and engraved for other departments requiring the same, while presenting some advantages, is not free from objection, as it will introduce causes of delay and interfere with the departments' direct control of their own business.

Clause 6. No evidence has been produced to show that the proposed centralization of the surveys in one department will serve any useful purpose. That the various surveys can be carried out independently provided they have permanent reference marks in common, is shown by the experience of other countries where such surveys, although so carried out, have reached a high degree of perfection. The survey branches of the several departments have grown in answer to the departmental means and their control by the respective ministers is absolutely necessary for prompt and efficient administration. A minister must have a free hand in administering his department and must not be hampered by having to transact part of his business through other departments. The material development of Canada is to a large extent dependent upon effective administration of public affairs; the country being young, the material interests are paramount and nothing must be allowed to stand in their way.

Clause 7. Under this clause, the departments are to be invited to carry out their surveys in accordance with such system as may appear best adapted to render the results of permanent value for topographic purposes. A general supervision of all surveys which it is proposed to assume cannot fail to prove objectionable to the other departments.

Clause 9. If the meaning of this clause is that a comprehensive survey of Canada can be carried out without a substantial increase in the appropriations, it is held that all the evidence available is against such a contention. It is simply proposed to spend a certain sum yearly for inaugurating a geodetic and topographic survey of the Dominion; the number of parties to be employed, their composition, the nature of the work and the methods to be used are all left for future consideration, as well as the

continuance or otherwise of the survey. Such a course was adopted by the conference held at Cape Town in 1904, and composed of the Cape Astronomer, a representative of the War Office, and the Surveyors General of all the colonies of South Africa, including Rhodesia. Like this committee, the conference was to formulate a scheme for the systematic survey of the whole of South Africa. The result of the deliberations is given as follows in the Annual Report of the Colonial Survey Committee, presented to parliament in October, 1906:

'A unanimous report was drawn up, but in the light of subsequent events it appears that the conference opened its mouth too wide. Some of the colonial governments found that the financial situation did not enable them to contribute the money required, and in May, 1905, the High Commissioner reported to the Secretary of State for the colonies that the scheme must be regarded as indefinitely postponed.'

The logical manner of dealing with the question is to decide first what work is to be done, how it is to be executed and what it will cost; the survey can then be proceeded with if the cost is within the limits of expenditure which the country can afford.

The money at present available is altogether inadequate to carry out a geodetic and topographical survey of Canada; if it is not to be very substantially increased, it might be used otherwise to more advantage in improving the maps.

Clause 10. The Surveys Board recommended by this clause is to suggest such regulations as it may consider necessary or desirable regarding all surveys and mapping. This recommendation, if acted upon, will to a considerable extent, withdraw the control of the surveys from the respective ministers and vest it in the board. It follows that when a minister requires a certain map or a certain survey for the proper administration of his department, he may have either to give it up because it is not in conformity with the regulations of the board or to accept a map or survey which does not answer his purpose as well. Such a scheme is impracticable; it has very little chance of being acquiesced in by the departments and will only serve to create difficulties.

E. DEVILLE,
*Surveyor-General.*

OTTAWA, March 1, 1907.

## COMMITTEE ON SURVEYS.

### MINORITY REPORT BY MR. STECKEL, REPRESENTATIVE OF THE DEPARTMENT OF PUBLIC WORKS.

OTTAWA, February 19, 1907.

The undersigned representative of the Public Works Department cannot for the following reasons, agree to approve the report of the Survey Committee constituted pursuant to an Order in Council dated November 15, 1906, as finally adopted February 15, 1907, by a majority of its members for submission to the Hon. the Minister of Militia and Defence.

He feels convinced, it would be a step in the wrong direction to create, as set forth in clauses six and nine of the said report, a distinct control department out of direct touch with the existing kindred services, by detaching from some of the present survey departments of the Dominion, those branches who have hitherto taken a hand in controlling ordinary topographic, hydrographic or levelling operations, and grouping them together in an entirely new department. In a young country like the Dominion of Canada, the aim of all government measures such as that suggested in the report in question, should be framed rather with a view of building up and im-

proving than tearing asunder existing recognized public services. As in this instance we have before us the fact that in no other country has similar grouping of controlled survey work been effected or found necessary, the adoption of such a course would inevitably have a pronounced tendency to belittle the importance of performing with due regard to accuracy, the special survey work that would be left in the hands of the public departments affected,—and would thus create the impression among many of the officials concerned, that the execution of the said special departmental survey work in an indifferent or slip shod manner, is considered to be a matter of but little consequence. Moreover, under present conditions much useful information for engineering purposes can frequently be secured in this young country at very little extra cost, by parties attending to control work who are also necessarily interested in the special work or services usually undertaken or carried on by the departments of which they form part, which would be completely lost to the government if the proposed segregation of special and control duties was effected.

Instead of raiding the departments where control survey branches have sprung into existence as a natural consequence of the progressive development of this young country during the past half century or so—and running the risk of losing the benefit of a large share of the experience gained in the departments in question during this long period—solely for the purpose of grouping together the more refined and scientific subdivisions of the services nurtured thus far in the said departments, and combining them all under a separate management which will be thus invited to pose as being of superior ability and importance, in some cases to the detriment of old officers who have inaugurated control services and devoted the greater part of their official lives to the improvement of the same—it appears to the undersigned to be far preferable and in the best interests of the Dominion, for the government to confine their action in this matter to placing the whole of the contemplated work of co-ordination, unification and control of the numerous diversified surveys at present undertaken by various public departments, on an equal footing in the hands of a representative commission( or advisory board) of experts, of similar composition to the survey conference just closed—who have the proper administration of the survey branches in question equally at heart from a national as well as from an economic standpoint; the prosecution of all the surveys required whether for special or general purposes being left to the same departments under whose charge such works have hitherto been carried on.

It may furthermore, not be out of place for the representative of the Public Works Department to call attention to the fact; that if the pet scheme of forming an exclusive model control department is unconditionally endorsed and the vaunted easy economical methods of procedure are strictly followed, one of the inevitable consequences will be the occurrence of vexatious delays in carrying the hydrographic surveys projected in different parts of the Dominion, primarily at places where they are shown to be most needed in the interests of navigation.

While the undersigned is practically in perfect accord with the majority of the members of the committee in regard to several of the views expressed in the report adopted by them—leaving aside in toto clauses Nos. 6 and 9 above referred—some of the other clauses of this report also contain suggestions which are materially at variance with those contained in the draft report embodying the views held by the Public Works Department he placed in the hands of the members agreeably to a decision reached at the evening meeting of January 24—which draft report reads as follows:—

'We, the members of the Survey Conference constituted in pursuance of an Order in Council dated November 15, 1906, for the purpose of securing a more perfect and complete co-ordination of the work of the existing survey branches of the different government departments, with a view to the inauguration of a systematic geodetic survey of Canada as soon as practicable, have the honour to submit the following conclusions and recommendations, viz.:—

In relation to Canadian government surveys, especially those undertaken in the better settled parts of the country, the elaboration and adoption of a comprehensive

scheme that will permit of a satisfactory co-ordination of existing survey material, supplemented when found necessary by complementary data, and of the prospective future rational extension of survey work—the whole with a view of eventually producing and issuing for public use accurate and instructive sectional maps covering the whole Dominion, is a matter of national importance and great practical utility to the people of Canada.

The reliable and varied information afforded by such maps undoubtedly is the means of effecting considerable economy in the location of trails, roads, railways, canals and works for water supply, drainage, irrigation and the like, has clearly proven on various occasions in the United States of America and in many European and other countries where such maps have been made and issued for the benefit of the public. These maps also enable the various public departments engaged on the surveys of the natural economic resources of the country to effect a saving of their outlays, by avoidance of duplication of field work in securing a basis for the graphical representation of the extent and importance of such resources.

For the proper co-ordination of existing surveys and the effectual control of future surveys, it is necessary to establish in a permanent manner a series of points of reference and bench marks, at convenient distances apart, whose geographical positions and absolute altitudes have been accurately determined by careful appropriate astronomical observations, chains of refined geodetic triangulations, and nets of precise spirit levelling.

Where properly conditioned geodetic triangulations are impracticable without entailing an unwarrantable expense, owing to the rugged nature, the distorted features or other unfavourable conditions of the country, the running of accurately oriented, measured and levelled traverse lines may be resorted to, which course constitutes a tolerable accurate and effective mode of control.

Provision should be made for applying to all surveys of standard accuracy made under Dominion authority, the rule just laid down for perpetuating principal bench marks, primary triangulation points, and other important points in the interior detail of government surveys by permanent monuments.

There should be established a central record office at Ottawa, in a suitable fireproof building where the results of all surveys, inclusive of exact copies of plans, profiles and cross-sections accompanied by brief summary descriptions, should be filed.

These drawings and descriptive memoranda should be made readily accessible to the public for purposes of reference, as well as to all administrative departments or other branches of the government service.

Deposit in this office of all such results, plans, or other documents should be made compulsory upon the public departments conducting surveys and upon all railway, bridge and other companies working under Dominion charter.

In order that the recommendations and conclusions above set forth may be gradually acted upon with due regard to economy consistent with efficiency, existing conditions and prospective requirements, the members of the present survey conference should be appointed to form part of a commission of experts, required to assemble under the presidency of the Hon. the Minister of the Interior or one of the other Ministers of the Crown at the head of the survey departments represented on this conference, who should be assisted by two vice-presidents and a secretary.

The duty of this commission would be to lay down the basis for the execution of the projected primary geodetic and accurate topographic surveys, inclusive of networks of precise levelling, and to select an executive committee of experts composed of say five or six of its members, to work out the details of the programme prepared by the commission, as regards the instruments to be used and the methods to be followed and frame the necessary regulations for ensuring the successful prosecution of both the field operations and office work involved in the production and publication—under a standard arrangement as regards scale, projection and execution—of the projected reliable and instructive sectional maps covering the whole Dominion

above mentioned; the prosecution of all the surveys required whether for special or general purposes being left to the same departments under whose charge such works have hitherto been carried on.

While the appropriations asked by the government from Parliament at its present session, to make provision for carrying on during the fiscal year ending March 31, 1908, the existing survey services of the Dominion—may remain at their present figures, pending further development in connection with the projected co-ordination, unification and control scheme—it is indispensable that a special appropriation of say $10,000 be obtained to provide funds for carrying on the work of the proposed commission, inclusive of reasonable allowances to be made to officers of the Civil Service called on to devote their spare time to the labours devolved on the commission and to place at its disposal the valuable knowledge they gained from the long experience acquired in following their respective callings, notwithstanding anything in the Civil Service Act.

Assuming that the federal authorities are firmly resolved to proceed with the commendable work of producing and publishing reliable and complete sectional topographic maps of the whole of those parts of the provinces and territories of the Dominion which are well fitted for settlement from the Atlantic to the Pacific coast—together with similar but less perfect maps of the districts less favoured by nature—and that they are prepared to carry on systematically the necessary field and office works on a scale commensurate with the importance and usefulness of this undertaking of truly gigantic proportions—it stands to reason that Parliament will have to be called on every year to grant materially larger appropriations to be devoted to the services affected by the contemplated expansion of the survey work now carried on than have heretofore been made for such purposes, for, the total cost of this great work will unavoidably run far into the millions of dollars.

R. STECKEL.

*C. A. Bigger to the Chief Astronomer.*

OTTAWA, Ont., August 5, 1908.

W. F. KING, ESQ., LL.D.,
*Chief Astronomer.*

SIR,—As an introduction to a description of the Geodetic work accomplished in Canada a short historical sketch may be of interest.

Geodetic Surveys for geographical purposes have been in active progress in many countries for more than a century. Their inception was due to the advancement and development of scientific research. A more exhaustive and intelligent discussion of the size and figure of the earth became necessary in order that the disputes between scientific societies in the different European countries might be satisfactorily settled. The early history of Geodetic work—prior to the beginning of the nineteenth century—is most interesting reading, but for the purpose of this report, may be passed over with a summary of its development.

The study of the size and figure of the earth is carried on by triangulation along arcs of meridians upon different portions of the earth's sphere, and necessarily includes astronomical observations for latitude and azimuth, thus supplying one of the two co-ordinates for mapping purposes. A desire for the comparison of results led to the connection of these triangulations transversely, which, together with the choice of a principal meridian, furnished the other co-ordinate called longitude.

The progress of civilization created a demand for accurate maps and the triangulations referred to, supplied stations of known latitude and longitude, thus bringing before the public the practical benefits of such work.

The earlier geodetic triangulations were for many reasons unsuccessful; no definite data as to the curvature of the earth's surface were derived therefrom, but the knowledge obtained served as an incentive to more work, and the rivalry between the countries more advanced in scientific knowledge became intense, especially in the fourth decade of the eighteenth century. In 1735 and 1736 expeditions were organized by the French Academy of Sciences and their work in Peru and Lapland proved that the polar is longer than the equatorial degree of latitude.

Towards the latter part of the eighteenth century, triangulations were in active progress in Great Britain and on the continent of Europe, and during the first decade of the nineteenth century the Great Triangulation Survey of India and the Geodetic Survey of the United States of America were commenced. The methods developed by these two surveys are recognized as the best modern practice.

## Beginning of the Geodetic Survey.

Up to the present, maps of Eastern Canada have been compiled from the plans of township surveys, co-ordinated—in some instances—by railway surveys. When greater accuracy was desired, latitude and longitude observations were made at isolated stations.

The requests for these astronomical stations became so frequent that it was deemed unwise to further postpone the beginning of a geodetic survey, as geographical stations—determined by astronomical observations—are subject to the influence of the unequal distribution of gravity, and their displacement from this cause alone may amount to several hundred feet.

## Work of 1905.

In 1905, the Chief Astronomer received the authority of the Minister of the Interior to commence a triangulation in the vicinity of Ottawa, and the writer was given charge of the work. On the 23rd day of July the first signal was erected on King Mountain, about nine miles northwest of Ottawa. (Plate 1). An observing tower eighty-seven feet high was erected the same season near Bowesville, south of Ottawa. (Plate 2). And a portion of the country between the Ottawa and St. Lawrence rivers was explored for the purpose of selecting angular points for the triangulation.

## Work of 1906.

In 1906, nine towers of an average height of seventy-five feet were erected and reconnaissance extended east and west from Ottawa. Up to the end of 1906 the work was of a desultory nature owing to the small amount of money available for that purpose.

During the winter of 1906 and 1907, the writer and one assistant continued the reconnaissance east from the city of Ottawa across the southern portion of the province of Quebec as far as the southeastern boundary of that province.

## Work of 1907.

In 1907 the Geodetic Survey of Canada was organized upon a somewhat more extensive scale and much work was accomplished during that season.

At the outset it was decided that the triangulation should be of the highest order of precision and the standard adopted, viz.: that the average summation of the three observed angles of each triangle should be within $180 + \epsilon \pm 1''$ has been attained as will be seen by the following table.

| Stations. | Observed Angles. | Spherical Excess. | Plane Angles. | Sum. | Error. |
|---|---|---|---|---|---|
| Bowesville | 43° 18′ 54″·42 | —0″·41 | 54″·01 | | |
| King Mountain | 79 14 47· 36 | —0″·41 | 46· 95 | | |
| Carp | 57 26 18· 96 | —0″·41 | 18· 55 | 59″·51 | 0″·49 |
| Bowesville | 48° 25′ 00″·52 | —0″·75 | 59″·77 | | |
| Montague | 47 30 57· 00 | —0· 75 | 56· 25 | | |
| North Mountain | 84 04 03· 92 | —0· 75 | 03· 17 | 59″·19 | 0″·81 |
| Bowesville | 30° 31′ 48″·89 | —0″·36 | 48″·53 | | |
| North Mountain | 71 05 28 88 | —0· 36 | 28· 52 | | |
| Ormond | 78 22 43· 43 | —0 36 | 43· 07 | 00″·12 | 0″·12 |
| Bowesville | 74 29′ 29″·25 | —0″·55 | 28″·70 | | |
| Navan | 59 41 56· 67 | —0· 55 | 56· 12 | | |
| Ormond | 45 48 34· 87 | —0· 55 | 34· 32 | 59″·14 | 0″·86 |

That precision fully equal to that of the principal geodetic surveys has been achieved is very encouraging, especially in view of the fact that the opinion has been often expressed, sometimes with assumption of authority, that Canadians, from want of experience, could not cope with the work, and that it would be necessary for the proper carrying on of a geodetic survey in Canada to resort to other countries for instructions in methods and even for the personnel of the survey. All the observers now on the staff are graduates of Canadian Universities.

## GENERAL REMARKS.

It was confidently expected that the experience of other countries would place geodetic operations beyond the experimental stage. As far as the perfection of angular instruments is concerned, those expectations have been realized. The angles of the triangles tabulated were measured with a twelve-inch, two microscope, Troughton & Simms theodolite reading directly to seconds of arc, designed for the Great Trigonometrical Survey of India. Unfortunately for the progress of our work, the adoption of apparatus for signalling—reported highly satisfactory in other countries—proved disastrous; it was found to be wholly inadequate to cope with the atmospheric conditions prevalent in eastern Canada. The Geodetic Survey of Canada has been undertaken for practical purposes, viz.: the establishment of geographic positions for mapping, and for the present is confined to the older and more thickly populated sections, without any regard to their suitability for primary triangulation. Much of this work in other countries is carried on solely for the purpose of adding to their scientific knowledge, and the localities for measuring arcs of meridians and parallels of latitude are chosen after duly considering the physical and atmospheric conditions to be encountered.

Although for the present the public utility of the work is dominant, it is hoped confidently that our survey may eventually be used to add to the knowledge of the 'figure and size of the earth' and that in this respect the scientific work of Canada may not remain behind that of other countries.

## DESCRIPTION OF METHODS ADOPTED.

The triangulation by means of which a geodetic survey is spread over a country, is expanded through three, four, five and even six sided figures—from a base line the length of which is carried through the figures by means of the triangles into which they are subdivided. The computation consists of an equal distribution of station

errors and an apportionment of the remaining errors of closure of the triangles by means of an elaborate least square adjustment having for its object the determination of the most probable values of the measured angles. In this connection the following extract from 'Instructions' issued to observers is of interest.

EXTRACTS FROM INSTRUCTIONS ISSUED TO OBSERVERS.

'The most important geodetic observations are those determining the angles between the lines radiating from the station occupied. The skill, patience and constantly watchful care of an observer entrusted with this portion of the work count for their full value. Office computations of the most refined and exhaustive nature can only make the best possible use of the material in the records of observations sent in from the field; they cannot in any way compensate unskillful or indifferent observations, as errors introduced in this way are to a large extent local, especially when the observations are made under unfavourable local atmospheric conditions.'

The unfavourable atmospheric conditions referred to above are also dealt with in 'Instructions to observers' as follows:—

'Observations in connection with primary triangulation for determining geographic positions must not be made when unfavourable atmospheric conditions exist. When the tests outlined by these instructions show that they may be made with confidence, observers and their assistants are expected to continue their work to the limit of physical endurance, that is, to that stage when personal equation becomes a variable. A pencil of light many miles in length near the surface of the earth is subjected to local atmospheric influences which will cause deflections uncertain in magnitude and direction, and, owing to the diversity of conditions along the lines of sight radiating from a trigonometrical station, the amount and trend of these local disturbances are impossible to estimate. A careful study of the physical features along the lines of sight will enable the observer to reach fairly accurate conclusions as to where such deflections may be expected. The pencil of light in its passage from a distant heliotrope or lamp to the observer's telescope encounters atmosphere varying in temperature and density governed by adjacent hills, masses of timber or low lying cultivated levels. When the line of sight is from hilltop to hilltop high above the intervening country, the conditions are most favourable, but if a hill rises on one side of the line, lateral displacement must be expected especially if wind is blowing from the hill across the line. When there is wind blowing towards the hill, pointings may be made with confidence'.

'Day observations of primary directions are not desirable, but during the autumn months they may be made when conditions appear favourable. For your guidance in this respect and as a criterion at all times, you are instructed to proceed as follows:

'Direct your telescope to a distant heliotrope or lamp—preferably along the most unfavourable line—and observe carefully for not less than ten minutes, the action of the image. If the vibration is rapid and uncertain as to direction, but symmetrical in magnitude and covering a small area, careful bisections of this area may be made with confidence, but if you observe the image move slowly to one side and return with similar deliberation—even though the movement may appear uniform—your pointings would be of no value for primary work.'

Instructions embodying the principles governing the Geodetic Survey of Canada are in the hands of all observers. They are the measure of the standard of accuracy adopted, and their preparation has been influenced by a desire that the work should be as distinctly Canadian as possible. Extracts from these instructions are used for purposes of illustration, and also for the better understanding of this report.

DESCRIPTION OF METHODS ADOPTED—RESUMED.

Returning to the description of the form of the triangulation, the figures are so arranged that the computations of the sides may be made through at least two series of triangles. This is accomplished by central stations in the triangles as well as the

tive and six sided figures. The diagonals of the quadrilaterals forming two triangles upon the same base are observed. The strength of the figures is measured by the relationship between the angles opposite the given and required sides of the triangles composing them.

Assuming the probable error of an angle to be one second of arc, the uncertainty in length caused by that error, as indicated in the sixth decimal place of the logarithmic sines of the angles used in the computation, may be conveniently tabulated for use in the field. In Canada we have secured the best possible figures on the ground to be covered, always having in view the public utility of the survey, as measured by the number of geographical positions determined. The physical features of Canada are not suitable for the formation of geodetic figures upon rigid mathematical principles, but up to the present no difficulty has been experienced, probably owing to the thoroughness of the reconnaissance survey.

The field parties employed during the season of 1907 were as follows :

One Signal Building Party, consisting of a foreman, assistant foreman and five men to build signal towers.

One Observing Party, consisting of one observer, one recorder, one cook and eight light-keepers, to observe the angles of the triangles.

Two Levelling Parties, of one observer, one cook and four men each.

In addition to the above, two assistants were employed on reconnaissance for the purpose of extending the triangulation southwesterly towards Toronto.

## SIGNAL TOWERS.

The erection of the high towers at the angular points to overcome the timber is most tedious and laborious. The plan adopted for these structures is a modification of one designed by Sergeant Beaton of the Royal Engineers of England (See Col. Clarke's Geodesy, page 181). The towers of the present day are of much smaller timber, but, owing to the stresses introduced and the general form of construction, are more rigid than the older and more expensive structures. They consist of a tripod upon which the theodolite is mounted and a scaffold insulating the observer's weight from the instrument.

The main objections to high tripods are their unsteadiness in wind and liability to torsion caused by unequal heating of the members during the day, followed by cooling at night. The former has been largely overcome by use of sway braces to stop vibration set up by the diagonals, and the latter by using dry timber throughout, the lumber being cut and stored at a central point a year ahead of the construction party.

The building party of 1907 made good progress and at the end of that summer all the towers between a line joining Covey Hill and Montreal—to the east—and Pakenham and Edwardsburg to the west, (see map accompanying this report)—were completed. Six towers were also built for the purpose of extending the United States Lake Survey from Lake Erie across the Niagara escarpment and Lake Ontario to Toronto, for the purpose of establishing geographical positions for maps under preparation by the Department of Militia and Defence.

The manner of erecting these towers is fully illustrated by plates from photographs taken at the different stages. This system is used for towers as high as eighty seven feet. The sections above that height are raised from the ground by block and tackle. The highest tower erected to date is one hundred and two feet from the ground to the lamp stand. Towers of this height are at Maxville, Westport, Binbrook and Grand River. The largest timber in their bottom sections is seven by seven—the central sections six by six and the top sections five by five inches. They are apparently as rigid as the lower towers and perfectly satisfactory in every way.

Nothing larger than six by six inches is used in the towers eighty-seven feet high. The following is a table of the number of feet, board measure, in the different heights of towers.

| | | | | | | |
|---|---|---|---|---|---|---|
| 102 | foot | tower | 6,200 | feet | board | measure. |
| 87 | " | " | 4,600 | " | " | " |
| 77 | " | " | 4,200 | " | " | " |
| 67 | " | " | 3,300 | " | " | " |
| 47 | " | " | 2,200 | " | " | " |

### THE OBSERVING PARTY.

During the season of 1907 a twelve-inch Troughton and Simms Theodolite with two micrometers reading to single seconds was used for measuring the angles (see plates 8 and 9), and what is known as the direction method was adopted. The routine is as follows. The most prominent station visible from the observer's tower is chosen to be used as an initial. The telescope is pointed on this station and then on all the other stations in rotation around the horizon clockwise, until the station preceding the initial is reached. The instrument is reversed upon this station and pointings made in the reverse order back to the initial. The micrometers are read forward and backward in conjunction with each pointing. Assuming that twisting—or torsion—of the high tripods is regular and the pointings made at equal intervals of time, the mean of the pointings will be free from any error from this source.

A determination of the angles at a station consists of sixteen pairs of pointings upon each signal. The zero on the azimuth circle for the pointings upon the initial is moved eleven degrees or thereabouts at the beginning of each set. The pointings in the day time are made upon heliotropes, and at night upon eight-inch acetylene reflectors in charge of men trained for that purpose. The observer instructs the light-keepers by means of the Morse alphabet and a pre-arranged code of signals.

The determination of the direction of each line involves thirty-two telescope, and one hundred and twenty-eight micrometer pointings. Special precautions have been taken to avoid errors in the micrometer pointings caused by imperfect filling of the graduations. In this connection the following is an extract from the "Instructions to Observers."

"The illumination of the graduations on the azimuth circle must be sufficient to counteract side reflections. You are directed to use artificial light at all times, and to arrange the reflector so that the electric hand lamp may be held parallel to the graduations and the light reflected therein so as to illuminate both its edges equally. The reflectors are to be adjusted in position before commencing work and must not on any account be moved during the progress of an evening's pointings."

Owing to the prevalence of high timber on the ridges in Ontario, the lines of sight invariably pass close to the tree tops, so that the atmospheric conditions are extremely unfavourable for geodetic work.

### PRECISE LEVELS.

Two precise level parties were employed during 1907. The lines levelled followed the main line of the Canadian Pacific railway from Sherbrooke to St. Johns with branch lines along the Grand Trunk railway from Lennoxville and St. Johns; on the Canadian Pacific railway from Foster, and the Central Vermont railway from Farnham; south to the International boundary and also along the Grand Trunk railway from Lacolle Junction to Coteau Junction. The methods adopted are similar to those of the United States Coast and Geodetic Survey, and are without any special features of interest. The permanent bench marks are copper bolts in the masonry of the culverts and bridges of the railway. They will be described in our next report, which will contain the results obtained during 1907 and 1908. The progress of the work has been hampered by the insufficiency of the optical parts of the instruments in use, necessitating

short sights in order to obtain perfect definition. The limit of error allowed is $0'{\cdot}017\sqrt{M}$, "M" being the distance in miles. New instruments have been ordered from Messrs. Cooke & Sons, York, England. Much delay in their manufacture has been caused by the specification requiring the use of an alloy of thirty-six parts nickel and sixty-four parts iron for the telescope tubes and base castings, and an alloy of like proportions of nickel and steel—called invar—for the more important parts such as level tubes and mounts, the telescope draw tubes and the diaphragms carrying the reticules and their adjusting screws. The new instruments will be in use shortly and owing to the increased optical efficiency more rapid progress will be made, since speed in levelling is regulated largely by the length of the sights.

During the winter of 1907 and 1908 reconnaissance surveys were carried on in Western Ontario, Central Ontario and in the Province of Quebec. A progress map is submitted showing the work accomplished to date. The solid lines join the towers which have been occupied by the observing parties, the dash and dot lines the towers built but not occupied, and the dotted lines the points selected for towers to be built this season. These latter points are, of course, subject to revision as the work progresses.

A much more comprehensive and extensive scale of operations has been inaugurated for the present season of 1908. Two observing parties are in the field extending the observations both east and west; an examination of the map will show the work accomplished to date—indicated by the solid lines. This season has been extremely unfavourable for observing. The prevailing low barometer allows the smoke of the cities to spread out over the surface, effectually preventing the use of instruments on the longer lines of the triangulation.

The instructions for 1908 require the observers to close the circle, that is, to reverse on the initial station instead of on the next preceding one. This enables them to form a more accurate estimate of their work as they proceed. It also discloses any twisting of the tripods. As far as the results up to the present are concerned there is no indication of torsion, the closing of the circle upon the initial seldom being more than two tenths of a second more or less than 360°.

The permanent station marks in earth are as follows:—An underground mark consisting of a six-inch glazed sewer tile, twenty-four inches long, on end, flange down, in an excavation two feet square and six feet deep is placed under the instrument point. This pipe and the surounding space is filled with concrete up to the top of the pipe and a copper bolt six inches long and three-sixteenths of an inch in diameter, dull pointed at top, placed therein, centered under the instrument point. Over this and separated from it by a layer of sand, six inches thick, a surface mark of the same nature is embedded in earth instead of concrete. The top of this latter mark is eighteen inches below the surface. In addition to the underground marks an artificial stone monument is erected, usually upon the nearest limit between township lots. Upon the base of this monument a copper plate will be placed showing the latitude and longitude of the monument. The azimuth and distance from the station mark to the monument will be published as part of the description of the station.

On mountain tops, or where solid rock occurs, the geodetic point is marked by a round copper bolt, three quarters of an inch in diameter, "fox-wedged" and leaded in the rock, surrounded by an equilateral triangle with eight inch sides, cut with a chisel.

The top of the bolt is stamped with the official die of the Geodetic Survey of Canada as follows:—

Three other copper bolts the same size, at the points of arrows indicating by their direction the central point, are placed around the station as reference marks.

Signal building is also progressing more rapidly this season. Two parties—in all eleven men—are at work in Central Ontario making rapid and satisfactory progress, and it is confidently expected that all the towers included in the triangulation outlined on the map herewith will be completed by November 15. A small party of three men are preparing the stations east of the line joining Montreal and Covey Hill. Their work at the primary stations consists of placing the copper bolts, building lamp stands and preparing three concrete foot blocks for the legs of the tripod of the twelve-inch instrument to rest upon. At some of the stations it may be necessary to build towers. One of the party has been trained in that branch of the work and with the aid of two additional men, hired temporarily, they can build a tower any height required. The officer in charge of the party in the mountainous districts has been instructed to avoid tower building as much as possible, as it is more economical to clear away the timber.

In addition to the preparation of the primary stations, this party is putting in a number of secondary stations at points previously occupied by officials of the Department of Militia and Defence. Their connection with the primary stations, as well as their usefulness for defining the positions of church spires, factory chimneys or other prominent objects of a semi-permanent nature are deemed of importance. No towers are built over secondary stations, and the ordinary tripod signal for day observing is erected instead of a lamp stand for night work. This party is also entrusted with revision of reconnaissance.

## PRECISE LEVELS—RESUMED.

During 1908 two levelling parties are in the field, one extending the levels from Sherbrooke along the line of the Canadian Pacific railway to the International boundary, and the other along the Grand Trunk from Coteau to St. Polycarpe Junction, thence along the Canadian Pacific railway via Kemptville Junction to Prescott, thence westerly along the main line of the Grand Trunk railway. They are making good progress but their efficiency will be much greater when they are supplied with the new English levels referred to. We are indebted to the Boston and Maine, Grand Trunk and Canadian Pacific railways for permission to use hand cars on their roads.

## BASE LINES.

A base line has been selected at Coteau Junction. It follows the centre line of the right-of-way of the Grand Trunk railway's main line. Its length is about eight miles and its northeasterly extremity is about two miles east of Coteau Junction and the southwesterly terminus, a short distance west of River Beaudette station. The measurement of the base has been deferred until the completion of the standardizing building at the Observatory, in order that the iced bar apparatus may be used therein. Invar tape lines fifty metres long will be used for the field work, and their length referred to a comparator measured by the iced bar apparatus in the standardizing building. 'Invar,' the new alloy of sixty-four parts of steel and thirty-six parts of nickel, is a great boon to geodetic work. Its temperature co-efficient is so small that it may be used without the uncertainty of results due to the difficulty of ascertaining the mean temperature of the sections of a long ribbon of steel. Base lines from which geodetic triangulations are expanded, are now, owing to the increased facilities for their measurements, introduced at more frequent intervals, preferably at the junction of comparatively weak figures with those of great strength. For the purpose of our work in Canada it is considered better practice to select the sites for the base lines after the observing towers for the main figures are built, so that the expansion may be as direct and perfect as can be secured throughout the system. The absolute length

of a base line is, in the opinion of the writer, of minor importance when compared with the strength of the geometrical figures through which this measurement is carried and with the determination of their angles; an error in the length of a base line produces no distortion. Every possible precaution is exercised in the field and the 'Instructions to Observers,' are intended to be exhaustive in this respect. As the measurement of angles progresses, the positions of church spires, brick factory chimneys or other structures of a semi-permanent nature are determined with sufficient precision for geographical purposes. Zenith distances are measured to the tops of towers in order that their relative elevations may be known. Precise level lines will be connected with the towers at convenient points in order that with the aid of the zenith distances measured, the height of the geodetic stations above the level of the sea may be computed.

In conclusion, I desire to acknowledge the zeal and faithfulness of my staff of assistants. Those who have been entrusted with the control of the different branches of the survey have displayed an amount of pride in their work, certain to secure the very best results. The Geodetic Survey of Canada is in every sense a national undertaking and it is our aim to make the work a credit to our country.

C. A. BIGGER.

145 –7

FIG. 1—Signal on King Mountain.

FIG. 2—Observing Tower, eighty-seven feet high, near Bowesville.

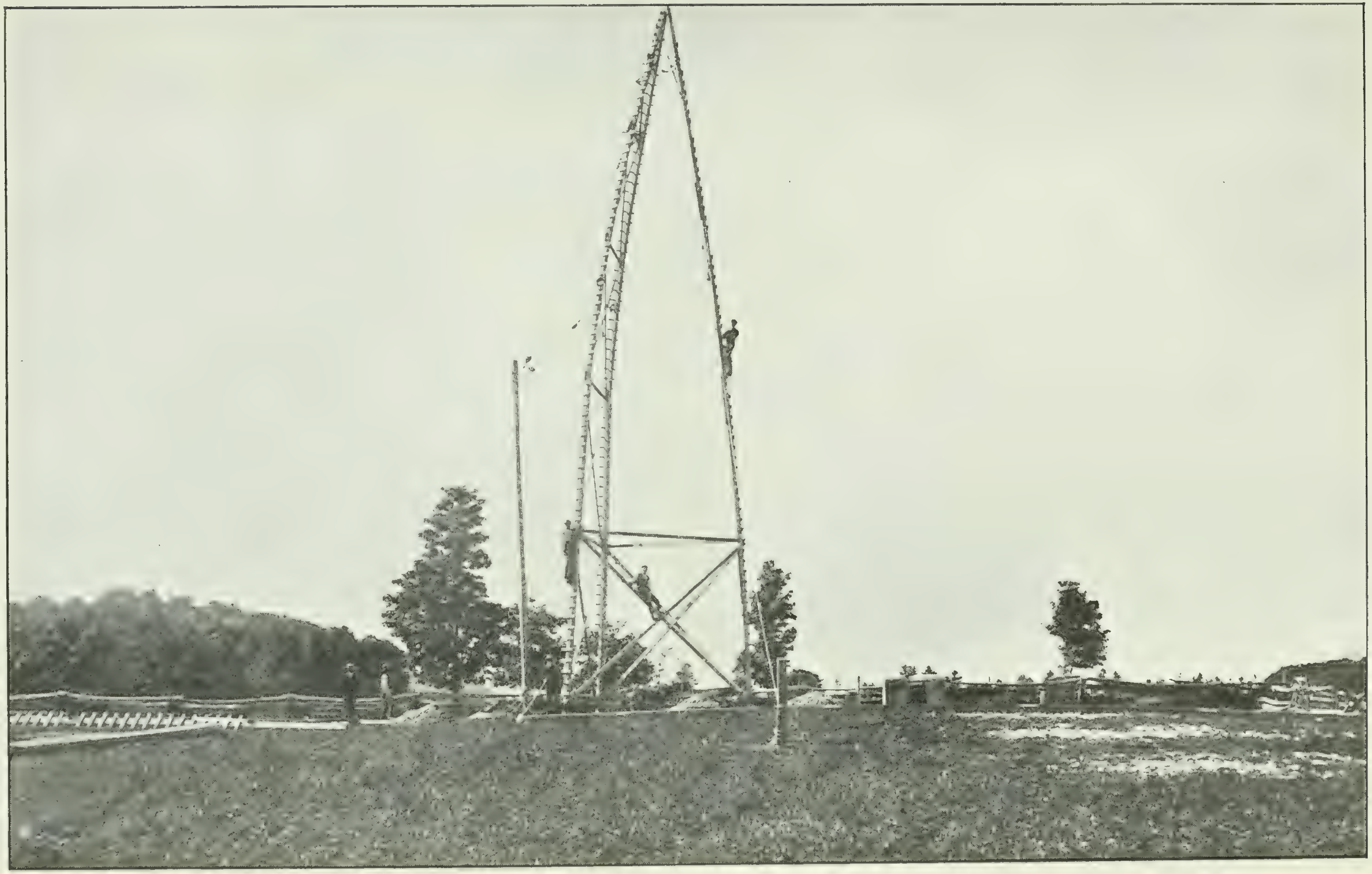


FIG. 3—Manner of erecting eighty-foot tripods.

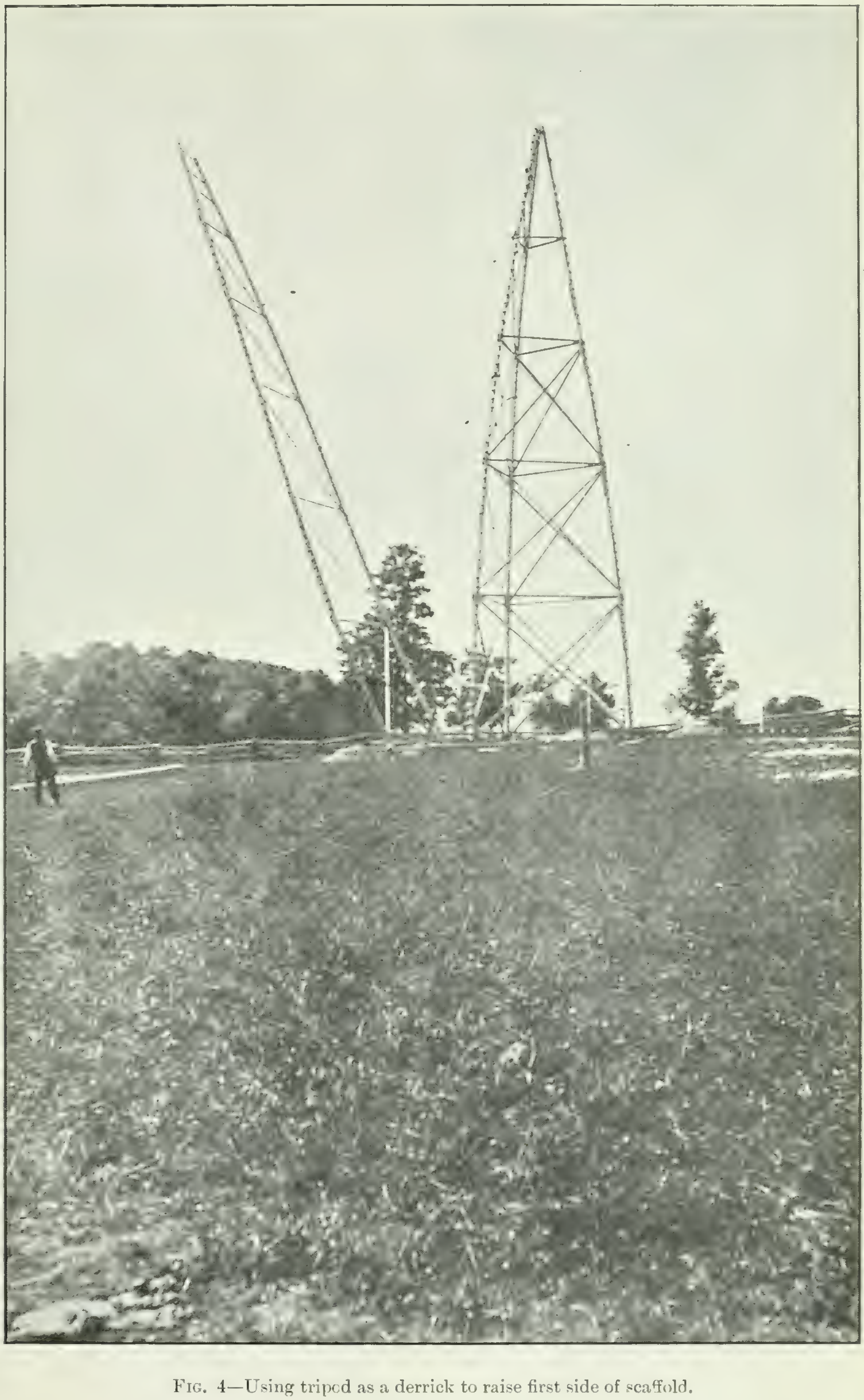


Fig. 4—Using tripod as a derrick to raise first side of scaffold.

FIG. 5—Turning side of scaffold on the ground before raising.

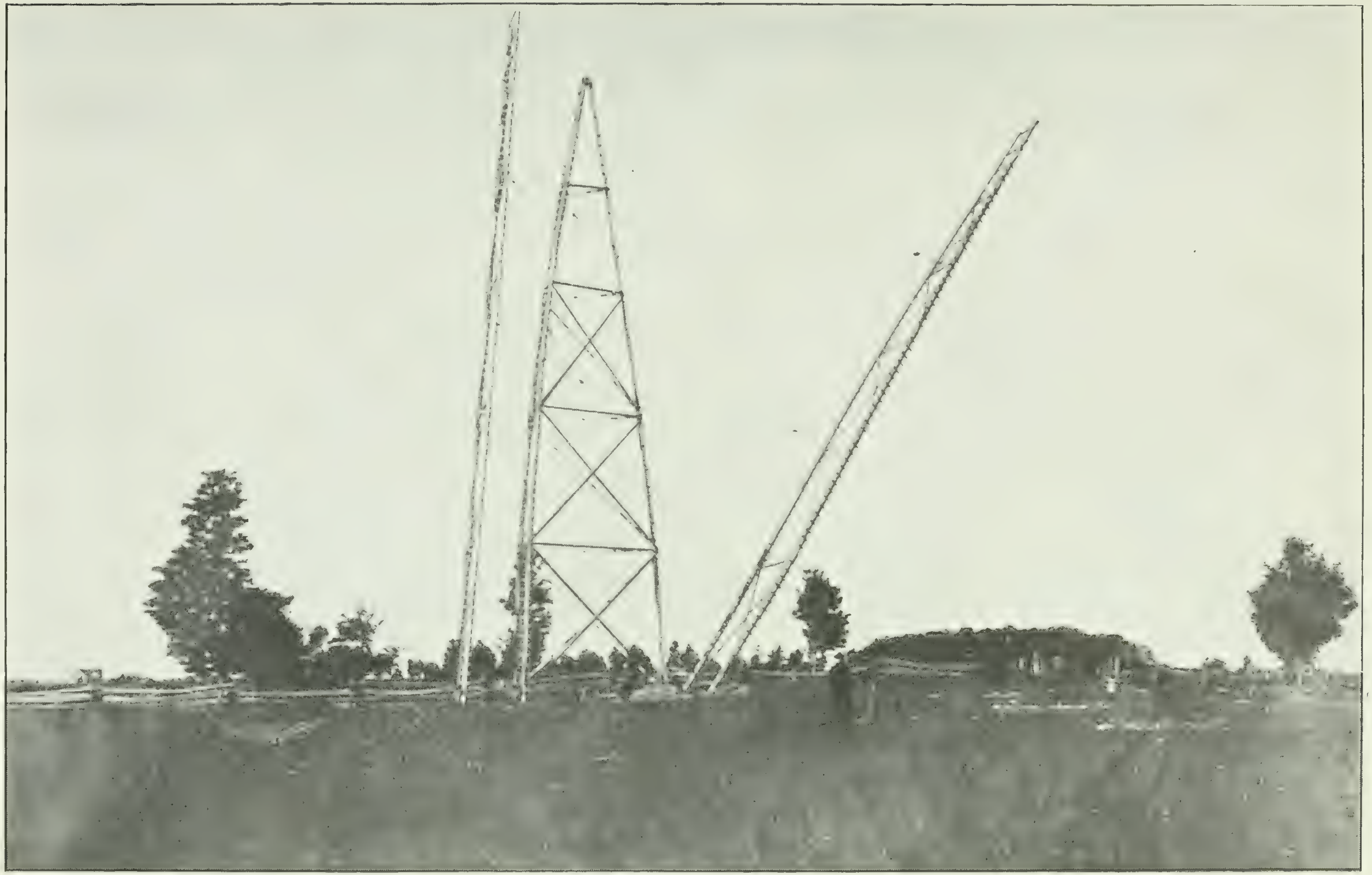


FIG. 6—Raising second side of scaffold.

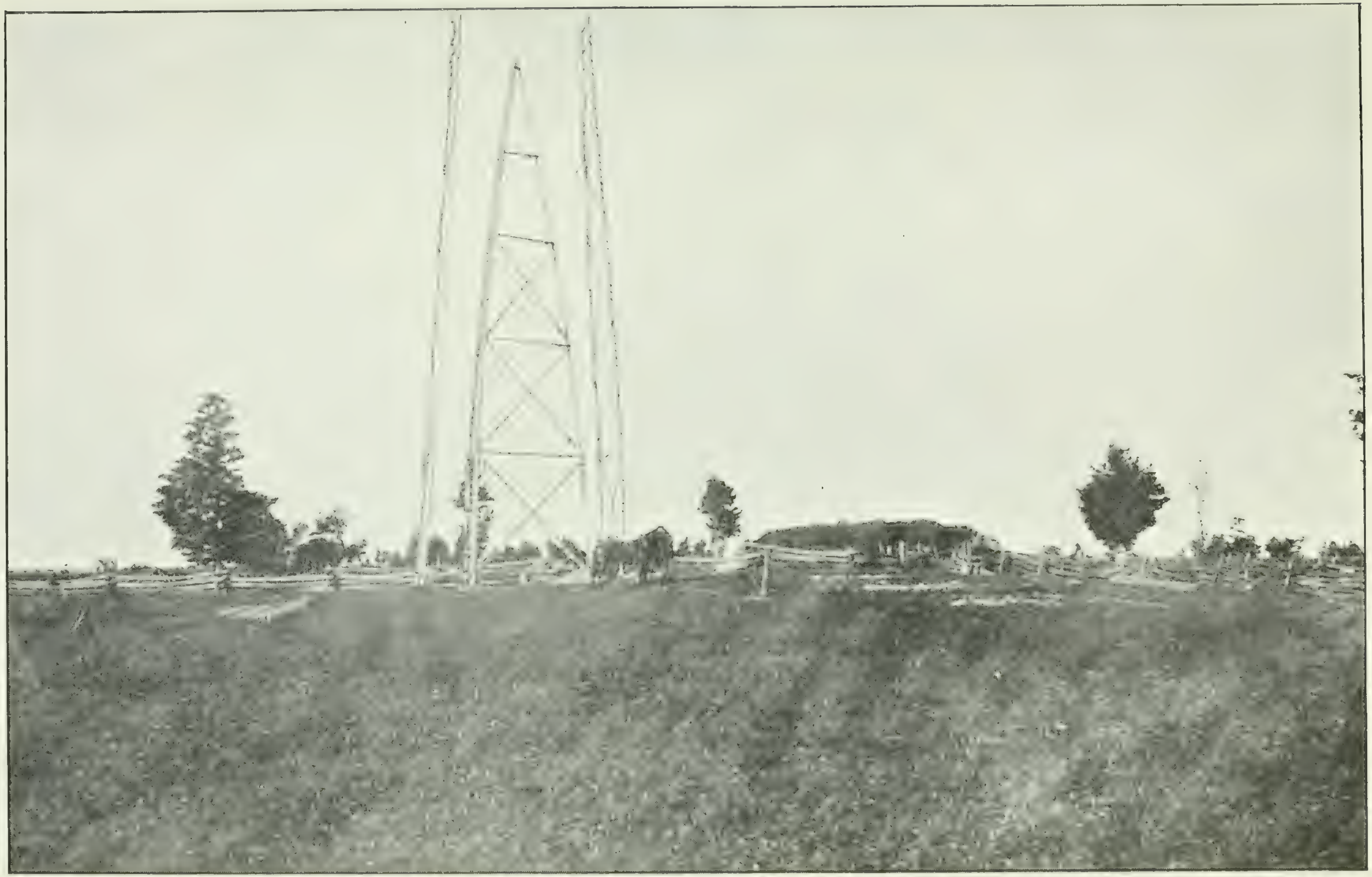


FIG. 7—Both sides of scaffold in place ready for spiking on ties and diagonals to complete the tower.

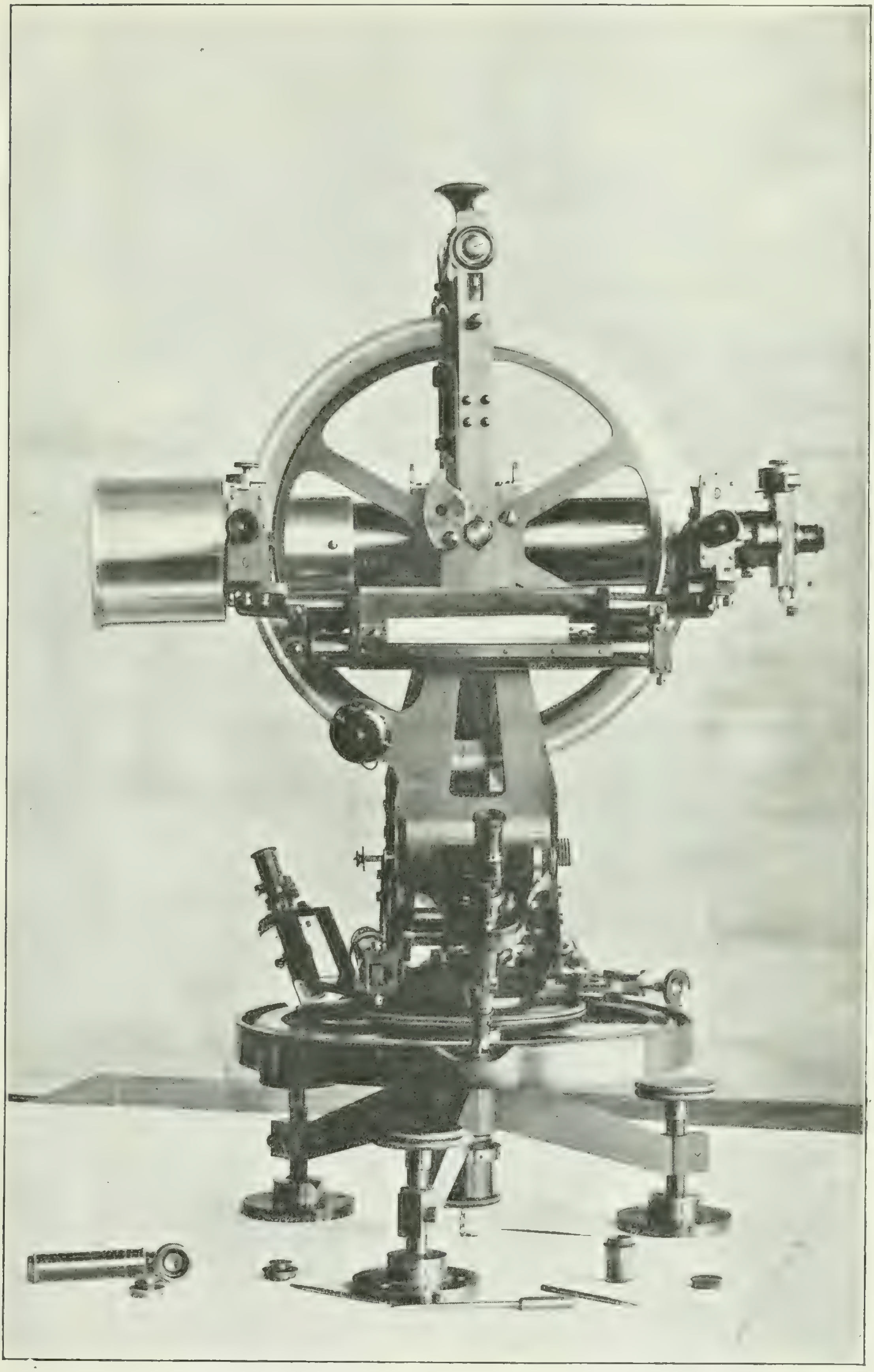


FIG. 8.—Side view of 12-inch Alt-azimuth Theodolite used for measuring horizontal and vertical angles.

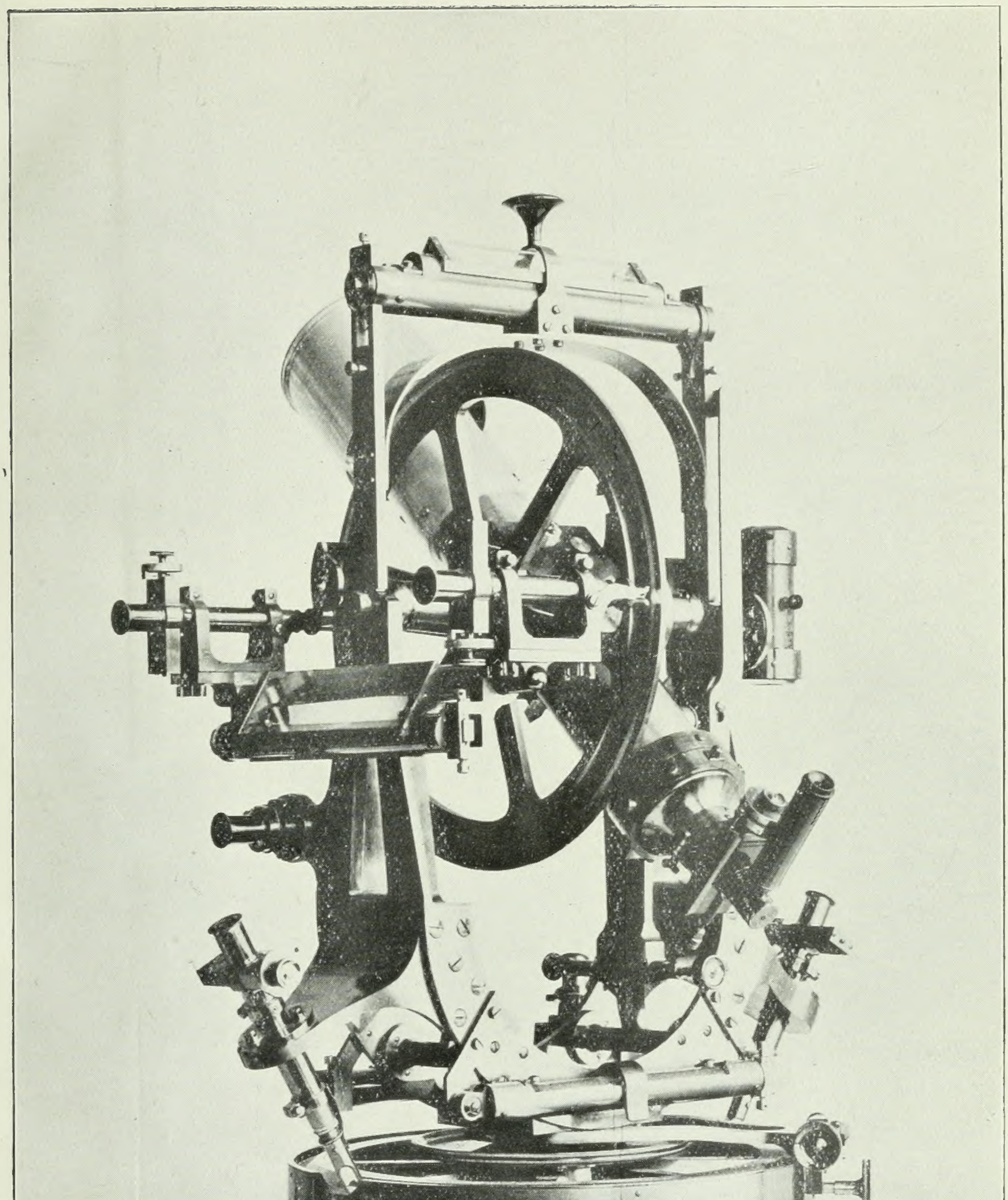
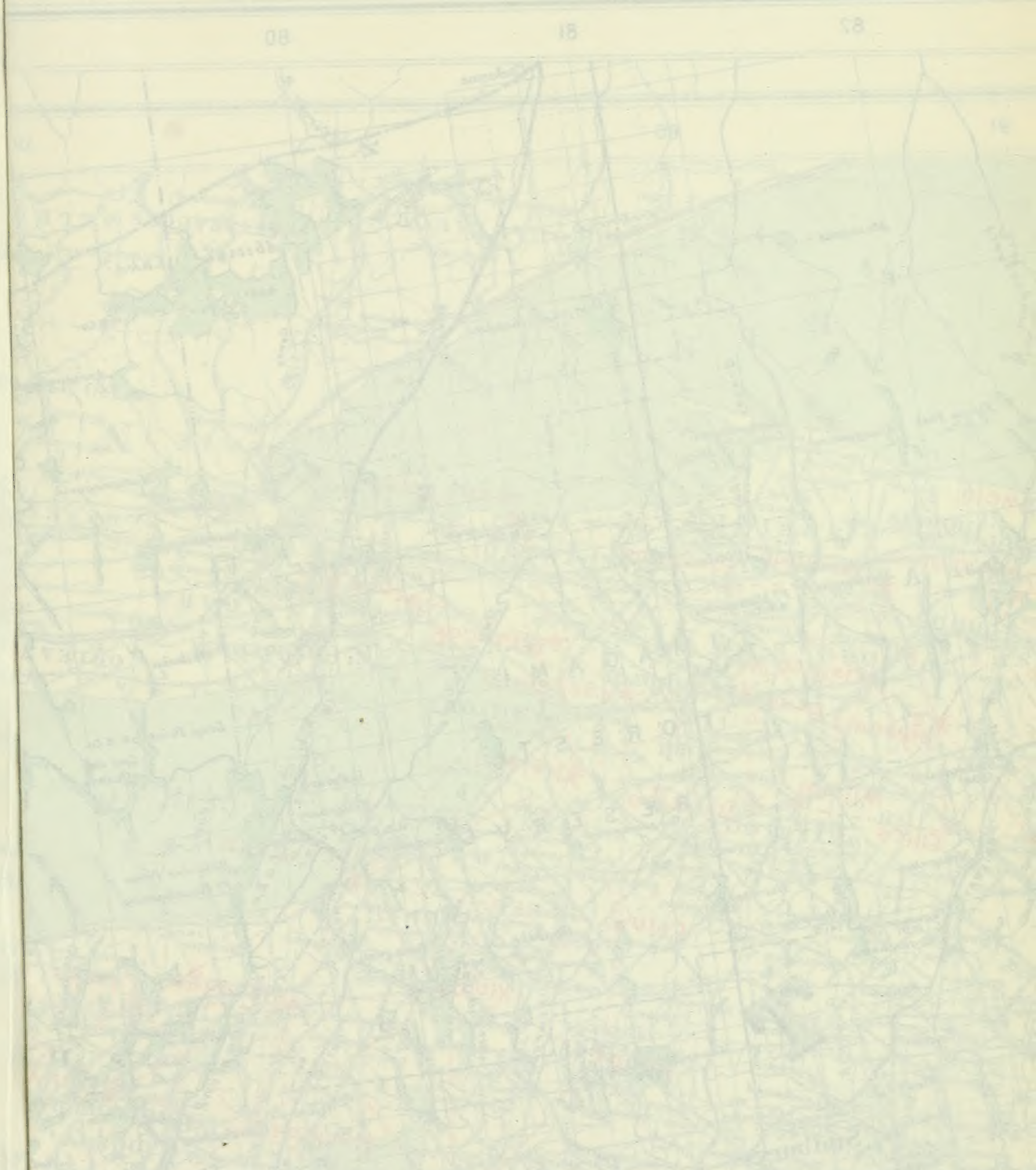


FIG. 9.—Half side view showing attachments of 12-inch Alt-azimuth Theodolite.




GULF
OF
St LAWRENCE
PRINCE EDWARD ISLAND
CAPE BRETON ISLAND
NEW BRUNSWICK
NOVA SCOTIA
MAINE
ONTARIO
QUEBEC
LAKE ONTARIO
LAKE ERIE
NEW YORK
Department of the Interior
HONOURABLE FRANK OLIVER, MINISTER
W.W. CORY, DEPUTY MINISTER
1908
PROGRESS MAP
OF THE
GEODETIC SURVEY OF CANADA
Scale, 35 miles to one inch.
James White, F.R.S.C. Chief Geographer
Lines connecting Towers that have been occupied by Observing Party
Lines connecting Towers, built, but not occupied
Lines indicating proposed figures; subject to revision